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Changes in State R&D Tax Credits**

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Why Do Innovative Firms Hold So Much Cash? Evidence from Changes in State R&D Tax Credits

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Abstract

This paper uses the staggered changes of R&D tax credits across U.S. states and over time as a quasi-natural experiment to examine the impact of innovation on corporate liquidity. By generating plausibly independent variation in firms' incentive to invest in R&D, we are able to assess the empirical importance of specific theories of the link between innovation and corporate liquidity. Firms increase (decrease) their cash to asset ratios by about one and a half percentage point when their home state increases (cuts) R&D tax credits. These baseline difference-in-differences estimates hold up to a battery of validation, falsification, and robustness checks, which corroborate their internal and external validity. The treatment effect of R&D tax credits increases monotonically with several specific proxies for debt and equity financing frictions. Increases (cuts) in tax credits also lead to increases (decreases) in the ratios of cash to bank lines of credit and to book equity, and to decreases (increases) in bank debt, secured debt, and overall net indebtedness, supporting debt and equity financing channels through which innovation impacts the demand for cash. We also find support for a product market competition channel, and assess repatriation and agency explanations. Overall, our analysis offers endogeneity-free evidence that innovation is a first-order driver of corporate liquidity management decisions.

1 Introduction

That the top U.S. cash holders are innovative corporations which rely heavily on R&D investments is well-known and to be expected based on first principles in corporate finance (for example, Aghion and Tirole (1994), Hart and Moore (1994)). In fact, innovative corporations held, on average, as much as a third of their assets in cash or near-cash instruments over the last decade, and the five largest cash holders were Apple, Microsoft, Google, Cisco, and Pfizer, who held more than one quarter of the total cash of the U.S. corporate sector. Especially since U.S. corporate cash holdings hit new record highs after the financial crisis, the subject of cash holdings of innovative firms has made headlines in the press and received attention by policy makers and institutional shareholder activists, with the likes of Carl Ichan and David Einhorn pressuring innovative firms to disgorge their cash.¹

However, what is relatively less well understood and remains actively debated is the question of why innovative firms hold so much cash. Is it because innovation matters for cash, or is it because innovative firms are just fundamentally different from the average U.S. corporation along observable and unobservable dimensions that are hard to control for? In addition, if innovation matters, *how* does it matter – i.e., through which channels does it impact cash? Despite the small yet growing literature on the financial economics of innovation, which has been generally focused on external rather than internal financing (Brown et al (2009; 2013), Chava et al (2013); Hall and Lerner (2010) is a survey), and the vast literature on the determinants of cash, which, starting from Opler et al (1999), has generally included R&D as a covariate for a large cross-section of firms, to date there has been no attempt at empirically identifying the impact of innovation on cash and at systematically evaluating the channels.

In order to fill the gap in the literature, we design a quasi-natural experimental setting that overcomes the empirical identification challenge of finding plausibly exogenous sources of variation in innovation by exploiting staggered changes in R&D tax credits across U.S. states and over time. One of the challenges with cross-sectional estimates is that measures of innovation are also correlated with proxies for why innovation matters, which complicates the examination of *how* innovation impacts corporate liquidity. By generating variation in firms' incentives to invest in R&D that is plausibly unrelated to firm-level characteristics, our quasi-experimental design also helps to overcome this issue. In summary, we offer well-identified estimates of the impact of innovation on cash, direct evidence that innovation is a first-order determinant of corporate liquidity, and a comprehensive assessment

¹See, for example, "Too Much Cash Isn't Good for Apple," BusinessWeek, February 26, 2013.

of the specific channels through which innovation impacts cash.

We start with presenting descriptive evidence that there is a positive cross-sectional relation between measures of firm innovation based on R&D expenditures and cash holdings relative to assets as well as external liquidity (bank lines of credit) in a standard panel of U.S. firms between 1986 and 2011. This evidence, which replicates in our sample the findings of Opler et al (1999) and Bates, Kahle, and Stulz (2009) for cash and Sufi (2009) for lines of credit, is important, but its interpretation is limited by a variety of well-known endogeneity concerns. In particular, when measuring the effect of innovation using comparisons across firms, there will always be a suspicion that the controls included in the analysis are not exhaustive. Such concerns are mitigated when the specification includes firm fixed effects. Nevertheless, if there are time-varying omitted firm characteristics, such as future profit growth opportunities, that affect both the firm's incentives to invest in R&D and its cash holdings decisions, then the estimates would not have a causal interpretation. As such, the cross-sectional evidence lays out the foundation for our effort to take a first step toward identifying the causal link between R&D and cash, and assessing the empirical relevance of the theories that can explain the link.

To achieve identification, we exploit plausibly exogenous time-series variation in firms' incentives to innovate that arises due to changes in state R&D tax credits.² By way of validation, we show that R&D expenses respond strongly to changes in state R&D tax credits, which is in line with the existing evidence on the effectiveness of tax incentives for R&D (see Hall and Van Reenen (2000) for a survey). In our baseline specification, we use a standard difference-in-difference (DID) approach to derive estimates of the effect of changes in state R&D tax credits on cash holdings. To insure that there are no systematic differences between treated and control firms that are relevant for their cash holding decisions, which is our key identifying assumption, we include an extensive set of controls for unobserved, time-invariant heterogeneity across firms; unobserved, time-varying heterogeneity across industries ("industry shocks"); and firm level changes in other determinants of cash holdings.³ The inclusion of these controls insures that our estimates are identified by comparing the differential (within-firm) response of cash holdings in the same industry-year for similar firms located in state-years when there is a change in the R&D tax credit (the 'treatment group') relative to those that are

²Over the last two decades, nearly every U.S. state has enacted some type of tax incentive for R&D and subsequently repealed, reduced, or expanded.

³To minimize the risk of biases arising from the inclusion of potentially endogenous variables as per the "bad controls" problem discussed in Angrist and Pischke (2009), we include the pre-treatment (lagged) values of the firm-level variables.

not (the 'control group').

Any residual identification concern about the internal validity of our baseline estimates can only come from residual unobserved, time-varying heterogeneity across states that is not captured by the industry-year effects, which may bias our estimates if it coincides with changes in state R&D tax credits and is relevant for cash holding decisions.⁴ We take several steps to build confidence that our estimates are well-identified. First, we implement validation tests of the main residual threat to our identification by examining the determinants of states' likelihood of changing their R&D tax credits, which we allow to be a function of state-level variables that, on an a-priori basis, we expect may be relevant for cash holding decisions, such as state business cycle and political conditions, labor market forces, and other state taxes. The results of these validation tests indicate that the introduction of R&D tax credits is the only type of change that is systematically related to state economic conditions and, in general, to state-level variables, while increases or cuts of R&D tax credits subsequent to their introduction appear generally unresponsive to state-level variables. Based on these results, we take a conservative approach in our baseline analysis and only include in the treatment group changes in state R&D tax credits subsequent to their introduction.⁵ Throughout the analysis, we take several additional steps to address potential state-level confounds and bolster a causal interpretation of our DID estimates, which include falsification and a battery of sensitivity tests.

Our baseline DID estimates indicate that there is an increase (decrease) in cash to book assets of about 2 (1.7) percentage points after an increase (decrease) in R&D tax credits, a result which is robust to using alternative definitions of cash ratios.⁶ To build confidence that these baseline estimates are well-identified, we implement two batteries of falsification tests.⁷ First, we repeat our analysis for two different sub-sample splits of the data based on proxies for the institutional design of the R&D tax credits that should affect their effectiveness because of the way they affect the opportunity-cost of R&D. The estimates indicate that there are strong and significant effects only for firms that are

⁴The reason why this issue is a potential challenge for our identification strategy is that it potentially threatens our key identifying assumption of "parallel trends" by which we are effectively assuming that absent a change in the state R&D tax credit, treated firms' cash would have evolved in the same way as that of control firms. Thus, we need to address potential state level confounds that affect firms' demand for cash irrespective of the R&D tax credits' changes.

⁵Since we recognize that tax credit introductions, though less suitable for standard DID research design, are potentially interesting discrete events, we examine their impact in an extensive set of dedicated robustness tests.

⁶There is no evidence of either firm anticipation or pre-event trends, while we also present evidence that larger tax credit changes trigger larger responses in cash.

⁷The specifications for both tests are all estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

subject to a stronger treatment. Second, we implement falsification tests that exploit changes in state investment tax credits, which are state-level tax incentives programs otherwise analogous to the R&D tax credits except for the fact that they give tax relief for capex – i.e., for investment in PPE, such as plants, machinery, and buildings.⁸ The response of cash to changes in investment tax credits, though somewhat weaker in magnitude, is qualitatively the exact opposite of the response to R&D credits, with cash decreasing (increasing) in response to increases (cuts) in investment tax credits.

We implement an extensive set of sensitivity tests to further corroborate both the internal and external validity of our baseline estimates. First, we estimate versions of our baseline DID regressions that use alternative standard errors⁹ and add more firm-, state-, and industry-level control variables, such as state fixed effects to control for unobserved time-invariant differences among states. Second, in an attempt to sharpen our identification, we refine the control group to include only firms in neighboring counties across border (see Homes (1998) for a similar approach) for which we can exploit the natural geographic discontinuity of tax policy (i.e., the fact that it stops at the state’s border) to difference out unobserved variation in local economic conditions.¹⁰ Third, we consider robustness to alternative estimators and assess the external validity of our baseline estimates. One of the alternative estimators we consider is a matched-sample DID estimator (Heckman, Ichimura, and Todd (1997)) that replicates the DID tests after matching treated and control firms based on pre-treatment characteristics that include state business cycle conditions, which further addresses the concern that differences between treated and control firms may invalidate our parallel-trend assumption.¹¹ To examine external validity, we include R&D tax credit introduction events in the treatment group. Our estimates remain stable across different specifications, estimators, and types of treatments. Overall, the results of our falsification, sensitivity, and external validity tests support a causal interpretation of the observed response of cash.

In the second part of our analysis, we investigate the drivers of the treatment effect by examining

⁸Chirinko and Wilson (2008) hand-collected state-level data on these programs and show evidence of their effectiveness at stimulating physical capital expenditures. We use their data to construct indicator variables for changes in state investment tax credits, which consist of 18 introduction events, 27 increases, and 8 cuts.

⁹Specifically, we cluster standard errors at the state level, to address the concern that clustering at the firm level may lead to inflated standard errors since the key source of variation in the analysis is at the state level (Bertrand, Duflo, and Mullainathan (2004))

¹⁰We do so by estimating a version of our baseline specification that adds county-pairs fixed effects and is estimated only for firms that have a neighboring county across the border. The resulting estimates are identified within contiguous county dyads across state borders.

¹¹ We also consider the system IV-GMM of Blundell and Bond (1998) to address potential biases from including a lagged dependent variable; and an IV-DID (2-SLS) estimator that uses R&D tax credit changes as instruments for changes in R&D capital, to offer well-identified estimates of the impact of R&D on cash (see Bloom, Schankerman, and Van Reenen (2013) for a similar approach).

its variation with several variables that, based on theory, we expect should affect the demand for cash by innovative firms. We start by testing whether the treatment effect displays systematic heterogeneity across variables that capture financing frictions.¹² The findings indicate that R&D tax credits have a stronger impact on cash for firms that have relatively less access to either debt or equity financing.¹³ To the extent that physical assets are relatively more suitable than intangible assets to support debt financing, the evidence from our falsification tests supports theories of cash based on debt financing frictions such as Rampini and Viswanathan (2010) and Falato, Kadyrzhanova and Sim (2013). To offer a more direct assessment of financing frictions, we also examine the impact of changes in state R&D tax credits on corporate liquidity structure, debt, and equity financing. Increases (cuts) in R&D tax credits lead to increases (decreases) in cash relative to bank lines of credit, and to decreases (increases, though estimates of these increases are noisy) in bank debt, secured debt, and overall net indebtedness. They also lead to increases (decreases) in net equity issuance, though cash increases also relative to book equity. In all, this evidence indicates that external financing frictions are an empirically relevant explanation for why innovative firms holds more cash, and that this is due not only to debt financing frictions, which have been the traditional focus of the existing literature surveyed in Hall and Lerner (2010), but also to equity financing frictions, whose importance has been recently emphasized by dynamic corporate finance models such as Bolton, Chen, and Wang (2011), Eisfeldt and Muir (2013), and Warusawitharan and Whited (2013).

We also test for variation in the treatment effect by proxies that capture other important theories, including agency frictions, repatriation, and product market competition. Specifically, we run our baseline DID regressions for splits of the data based on ex-ante proxies for repatriation incentives and product market competition,¹⁴ as well as of the severity of agency frictions faced by the firm.¹⁵

¹²Specifically, we split the sample between above versus below median (pre-treatment) values of the following variables: firm size, Kaplan and Zingales (1997) KZ-Index, Whited and Wu (2006) WW-Index, firm cash flows, firm age, firm market-to-book ratio, firm cash flow volatility, and by dividend payer status, as well as several other proxies for debt and equity financing frictions.

¹³To assess debt frictions, we run our baseline DID regressions of cash holdings for three different sub-sample splits of the data based on ex-ante proxies for the severity of the debt financing frictions faced by firms: Berger et al. (1996) asset liquidation value, Balasubramanian and Sivadasan (2009) index of industry asset redeployability, and based on whether the firm has a long-term debt rating. For equity frictions, the sample is split based on the total dollar volume of SEOs in a firm's (48-FF) industry in any given year, the average (0, +1) cumulative abnormal return (CAR) of SEOs announcements in a firm's (48-FF) industry in any given year, which are commonly employed proxies for hot vs.cold equity markets (e.g., Korajczyk and Levy (2003), and the standard deviation (dispersion) of analysts' EPS forecasts from IBES.

¹⁴The sample is split between above versus below median (pre-treatment) values of the foreign tax burden measure of Foley, Hartzell, and Titman (2007), based on whether the firm reports foreign income in a given year, and based on above vs. below median (pre-treatment) values of the (48-FF) industry Herfindahl-Hirschman Index (HHI) of sales.

¹⁵We report results for the sub-sample of firms in relatively concentrated industries (those with above-median HHI) and further stratify the sample based on above vs. below median (pre-treatment) values of

The response of cash to changes in state R&D tax credits is weakened by firms' multinational status, suggesting that the effect of increasing domestic financing frictions is empirically the driving factor of the repatriation channel, while the response is magnified by the intensity of industry competition, which supports recent theories such as Morellec, Nikolov, and Zucchi (2013) and Ma, Mello, and Wu (2013) where cash holdings strengthen the competitive position of firms vis a vis their industry rivals. The response is also magnified by proxies for agency issues between managers and shareholders, but only in relatively concentrated industries. This evidence is in line with the findings of significant interaction effects between governance and industry (Giroud and Mueller (2011)), and suggests that in relatively less competitive industries classical agency considerations of the type highlighted in the empirical literature by Dittmar and Mahrt-Smith (2007) and Gao, Harford, and Li (2013) are likely to be most important for innovative firms.

In summary, our paper makes three main contributions. First, we document the first evidence of a causal relation between innovation and corporate liquidity. Our evidence shows that innovation is a first-order driver of corporate liquidity decisions. As such, it complements existing findings in the literature on the financial economics of innovations (e.g., Brown et al. (2009, 2013), Chava et al. (2013)), which has so far mostly focused on external finance. It also complements the earlier cross-sectional findings of Opler et al (1999) and Bates, Kahle, and Stulz (2009) for cash and Sufi (2009) for lines of credit by indicating that a causal interpretation of these correlations is warranted. Second, we clarify how innovation impacts cash. By identifying the channels through which innovation affects firms' corporate liquidity decisions, we are able to make progress on the question of why innovation matters for corporate liquidity, which is challenging in a standard cross-sectional setting since measures of innovation tend to be correlated with proxies for why innovation matters.

Our findings have important implications for the ongoing policy debate, and are helpful to identify when in the cross-section shareholder activists' pressure on innovative firms to disgorge their cash is more likely to be beneficial. In particular, they indicate that financing frictions and competitive pressure lead to significant trade-offs for such shareholders' efforts. On the other hand, strategies targeting the cash holdings of entrenched firms in relatively less competitive sectors are likely to be value enhancing. Finally, at a more methodological level, our paper joins a recent literature that exploits state and country level changes in taxes to achieve identification (Heider and Ljungqvist (2012), Panier, Pérez-González, and Villanueva (2012), Faccio and Xu (2011)). Our contribution to this literature is to provide standard metrics for the likelihood of managerial entrenchment, which include board size, board independence, and whether the firm has a classified board of directors.

ture is to examine R&D tax credits and corporate liquidity, which broadens the focus of existing work on corporate profit taxes, debt tax shields, and capital structure. In doing so, and by documenting a stark contrast in the response of cash to changes in tax credits for R&D versus those for physical investment, we also contribute to the policy evaluation literature that examines the effectiveness of R&D tax credits as incentives for innovation (see Hall and Van Reenen (2000) for a survey, and Chirinko and Wilson (2008) for evidence on the effectiveness of investment tax credits), which had not examined corporate finance issues.

2 Theoretical Framework and Descriptive Evidence

In this section, we first provide an overview of the main theories that help to pin down the channels through which innovation should matter for firms' cash holding decisions. We then offer descriptive evidence that in our sample replicates the well-known finding that high R&D firms hold more cash – i.e., that there is a positive correlation between R&D and corporate cash holdings. This evidence suggests that innovation is a potentially important economic determinant of corporate cash management policies, but its interpretation remains yet unclear. As such, it lays out the foundation for our effort to take a first step toward identifying the causal interpretation of the correlation between R&D and cash, and assessing the empirical relevance of the alternative theories that can explain the impact of innovation on cash.

2.1 Why Should Innovative Firms Hold More Cash? An Overview of the Theory

There are several reasons to expect that, based on first principles in corporate finance theory, innovation should lead to higher cash holdings. First, a central insight of financial contracting and, more broadly, capital structure theories in corporate finance is that external finance frictions give rise to a precautionary or hedging motive to hold cash. This insight, which dates back to Keynes (1936), was developed in the influential study of Froot, Scharfstein, and Stein (1993)¹⁶ and has been recently explored quantitatively within dynamic corporate finance models (Riddick and Whited (2009) and Bolton, Chen, and Wang (2011)). A demand for internal funds arises because financial frictions limit the firm's ability to raise external finance. Due to such frictions, cash flow shortfalls might prevent

¹⁶See Almeida, Campello, and Weisbach (2004) for supporting evidence based on the cash-flow sensitivity of cash; and Bonaime, Hankins, and Harford (2013) for more recent evidence of substitution between hedging and payout decisions.

firms from investing in profitable projects if they do not have liquid assets. Thus, firms may find it profitable to hold internal finance (cash) in order to mitigate costs of financial distress and preserve investment opportunities.

There are two distinct financing channels through which R&D may increase cash by raising external finance costs. There is a debt financing channel, through which R&D limits firms' ability to raise debt since knowledge assets have limited collateral value (e.g., Hart and Moore (1994), Rampini and Viswanathan (2010), and Falato, Kadyrzhanova, and Sim (2013)). Based on this literature, R&D may limit external debt financing because it complicates contractibility problems by lowering the value that can be captured by creditors in default states. In addition, debt finance can lead to problems of financial distress that may be particularly severe for firms that rely heavily on R&D, since the design of standard debt contracts does not work well for investments characterized by a high probability of failure and some chance of extremely large upside returns (Opler and Titman (1994)). The debt financing channel also has direct implications for liquidity structure, and it implies that R&D should reduce firm reliance on external sources of liquidity, such as bank lines of credit.¹⁷

There is also an equity financing channel. Basic considerations from information theory suggest that R&D investments are prone to potentially severe information problems that are likely to increase the cost of raising external equity. Bolton, Chen, and Wang (2011) show that costly equity financing can give rise to a precautionary motive to hold cash. While external equity may have advantages over debt for financing R&D,¹⁸ internal and external equity finance are not perfect substitutes since public stock issues incur sizeable flotation costs and require a "lemons premium" due to asymmetric information (e.g., Myers and Majluf (1984)). Information asymmetries are likely to make outside equity financing more expensive when firms rely more on R&D, because due to the inherent uncertainty associated with R&D investment outside investors have more difficulty distinguishing good projects from bad compared to investments in more low-risk projects such as those in capital expenditures (Leland and Pyle (1977)).¹⁹

¹⁷See Mann (2013) and Chava, Oettl, Subramanian and Subramanian (2013) for recent evidence on debt financing and innovation. Hall and Lerner (2010) is a survey.

¹⁸For example, see Brown, Martinsson, and Petersen (2013), who document in a cross-section of countries that shareholder protections and better access to stock market financing lead to higher R&D investment, particularly in small firms, but are unimportant for fixed capital investment.

¹⁹A final financing aspect of R&D that favors cash is its inflexibility, which is due to the fact that R&D investment entails large adjustment costs. For example, R&D investments include setting up and running R&D labs with highly skilled workers, whose firing can result in large hiring and training costs as well as the unwanted dissemination of proprietary information on innovation efforts, making it very expensive for firms to cut down R&D in response to temporary changes in the availability of external finance. Consistent with this reasoning, Brown and Petersen (2011) document that financially constrained firms use cash to smooth their R&D expenditures. Relatedly, MacKay (2003) documents that there is a positive relation between leverage and

Second, the higher uncertainty and lack of verifiability associated with R&D may lead to an agency channel through which innovation impacts cash. This is the case if R&D makes insiders' decisions harder to monitor by outside shareholders, thus effectively exacerbating agency costs. The link between agency costs and cash is well understood at least since Jensen (1986), who emphasized the conflict between managers and shareholders over internal funds.²⁰ Relatedly, there is also a repatriation channel. The fact that multinationals have a motive for holding cash because their unrepatriated foreign earnings are tax advantaged is well established (see Foley, Hartzell, Titman, and Twite (2007) and Falkeunder and Petersen (2012)). However, innovation may either lower multinational firms' incentives to repatriate foreign income, by increasing financing costs at home, or it could heighten the repatriation motive by increasing the firm's flexibility to shift profits abroad. Thus, the overall effect of innovation on cash is ambiguous based on repatriation.

Third and final, there is a product market competition channel. A growing theory literature considers optimal cash holding decisions in a setting where firms compete dynamically over time (see, for example, Morellec, Nikolov, and Zucchi (2013), Ma, Mello, and Wu (2013); and Hoberg, Phillips and Prabhala (2014) for supporting evidence). Lyandres and Palazzo (2014) consider a setting where in addition to competing in the product market, firms also make innovation decisions. A common prediction across these theories is that the demand for cash should be increasing in the intensity of product market competition, and especially so for innovative firms. The basic intuition is that product market interactions give rise to a strategic motive for holding cash, by which cash holdings effectively improve the competitive prospects of a firm vis-a-vis its industry rivals.²¹ Thus, based on the product market channel, we expect that industry competition should increase the impact of innovation on cash holdings.

In summary, the theory literature leads to the following main testable hypotheses:

investment flexibility.

²⁰In a cross-country study, Dittmar, Mahrt-Smith, and Servaes (2003) document that in low investor protection countries firms hold more cash. Harford (1999) documents evidence that acquisitions by cash-rich firms are value-decreasing, which is consistent with private motives to hold cash. Dittmar and Mahrt-Smith (2007) find that the value of cash is significantly lower at poorly governed firms. More recently, Gao, Harford, and Li (2013) compare the cash policies of publicly-traded vs. privately-held firms, and argue that the large differences in cash holdings between these types of firms can be attributed to the much higher agency costs in public firms.

²¹He (2014) documents evidence in support of the product market channel, with R&D firms increasing their cash holdings in response to tariff reductions that lead to intensified foreign competition, but non-R&D firms not doing so. While informative about the importance of product market competition, this evidence still relies on a cross-sectional comparison between R&D and non-R&D firms, which may differ along observable as well as unobservable characteristics that are hard to control for. As such, it is less informative about the impact of innovation since interpretation is subject to the same type of endogeneity limitations as standard OLS estimates.

- Innovation should have a positive impact on cash holdings, but not on external (bank) liquidity.
- The positive impact of innovation on cash holdings should be stronger for financially constrained firms (debt and equity financing channels), for firms with more entrenched managers (agency channel), and those in more competitive industries (product market channel).

2.2 Data and Descriptive Evidence

Our primary data is standard accounting information from Compustat for all nonfinancial firms²² incorporated in the U.S. between 1986 and 2011, which yields a starting panel of 124,504 firm-year observations for 11,091 unique firms. 1986 is the earliest year for which we can retrieve historical information on firm headquarter location, which is necessary to implement our identification strategy as described in detail in the next section. We complement this sample with detailed information on firm liquidity and debt structure from Capital IQ, which is available for a sub-set of 23,086 firm-year observations for 2,866 unique firms in the 2002 to 2011 period (see Sufi (2009) for an early study of liquidity structure that uses hand-collected information from SEC filings, and Colla, Ippolito and Li, (2013) for a recent study of debt structure that uses Capital IQ). In order to better isolate the causal impact of innovation, it is important to minimize the risk that our estimates are driven by spurious correlation from comparing innovative to non-innovative firms, which differ along many dimensions that are hard to control for. In addition, tax incentives for R&D are clearly not relevant for firms that are not active in R&D, whose inclusion would reduce the power of our tests. Thus, we take a conservative approach and exclude firms that are never active in innovation throughout our sample period.²³

Table 1 provides summary statistics for our resulting final sample of innovative firms, which consists of 6,058 (1,798) unique Compustat firms (with Capital IQ information) that report non-zero R&D expenditures in at least one year over the 1986-2011 period for a total of 72,587 (14,504) firm-year observations. We report means, medians, and standard deviations of our main dependent variable, the ratio of cash holdings to book assets, as well as of liquidity structure variables, such as the ratio of bank liquidity to total liquidity. We also tabulate commonly employed measures of firm innovation, R&D expenditures and the stock of R&D assets,²⁴ and our firm- and industry-level controls, which

²²As it is standard in the literature, we exclude regulated Utilities (SIC 4900-4999) and firms with missing or non-positive book value of assets in a given year.

²³The results are robust to adding the more aggressive filter of excluding all firm-years with zero R&D.

²⁴Since under current accounting principles R&D assets do not appear in firm balance sheet, we follow an approach which is standard in the literature on the economics of innovation (Corrado, Hulten, and Sichel (2009) and Corrado and

include those generally used in the literature. Detailed variable definitions are in Appendix A. Overall, our starting Compustat sample is comparable to those used in previous studies, such as Opler, Titman, and Stulz (1999), with firms holding on average 18% of their total (balance sheet) assets in cash. In our final sample, innovative firms hold on average 24% of their total assets in cash, which is consistent with the well-replicated finding of a positive correlation between cash and R&D (Bates, Kahle, and Stulz (2009) and Hall and Lerner (2010)). However, innovative firms clearly differ from the average U.S. firm along most characteristics, including that they are generally smaller and younger, have higher growth opportunities, and are less reliant on debt and less likely to pay dividends, which illustrates one aspect of the identification challenge involved in deriving well-identified estimates of the impact of R&D on cash.

Before proceeding to our main analysis, Table 2 summarizes descriptive evidence on the cross-sectional relation between standard measures of firm innovation and cash holdings, as well as liquidity structure. Specifically, we report results of OLS regressions of cash-to-book assets ratios (Columns 1 to 4) and ratios of external liquidity-to-total liquidity (the sum of cash and external liquidity) (Columns 5 to 10) on (year-prior) R&D (expenditures or capital), while controlling for standard cross-sectional covariates of cash holdings (year-prior cash flow volatility, market-to-book ratio, firm size, cash flow, capex, acquisition expenditures, and a dummy for whether the firm pays dividend in any given year) in addition to year and 48-FF industry effects. In line with previous findings (Bates, Kahle, and Stulz (2009), Lyandres and Palazzo (2014), He (2014) for cash, and Sufi (2009) for liquidity) and with the evidence surveyed in Hall and Lerner (2010), the coefficient on either measure of R&D is statistically and economically significantly positive (negative) in the cash (external liquidity) regressions,²⁵ a result that holds in both the overall Compustat sample (Panel A) and our innovative firms sample (Panel B). Thus, consistent with theory, innovative firms tend to hold a relatively larger fraction of both their assets and their total liquidity internally in the form of cash.

Hulten (2010); see Eisfeldt and Papanikolaou (2011;2014) and Falato, Kadyrzhanova, and Sim (2013) for recent papers in finance that have used a similar approach to construct measures of intangible assets) and construct the stock of R&D assets by capitalizing R&D expenditures using the perpetual inventory method as follows: $G_{it} = (1 - \delta_{R\&D}) G_{it-1} + R\&D_{it}$ where G_t is the end-of-period stock of R&D capital, $R\&D_{it}$ is the (\$1990 real) expenditures on R&D during the year, and $\delta_{R\&D} = 15\%$ following Hall, Jaffe, and Trachtenberg (2001). If R&D expenditures are constant (in real terms), the stock of R&D capital is $G_t = \sum_{s=0}^{\infty} (1 - \delta)^s R\&D_{t-s} = \frac{R}{\delta}$. We set the initial stock to be equal to the R&D expenditures in the first year divided by the depreciation rate $\delta_{R\&D}$. In addition, we interpolate missing values of R&D following Hall (1993) who shows that this results in an unbiased measure of R&D capital. The R&D stock is scaled by (\$1990 real) book assets.

²⁵Coefficients on control variables are also in line with the previous literature, with large firms and firms that pay dividends holding less cash, and firms with higher cash flow volatility and market-to-book holding more. The coefficients on capital expenditures and acquisitions are negative and significant, consistent with firms using their cash holdings to pursue investment opportunities.

3 Exploiting Changes in State R&D Tax Credits: Baseline Estimates of the Impact of Innovation on Cash

The cross-sectional evidence on the relation between R&D and cash replicated in Table 2 is important, but its interpretation is limited by a variety of well-known endogeneity concerns. In particular, when measuring the effect of innovation using comparisons across firms, there will always be a suspicion that the controls included in the analysis are not exhaustive. Such concerns are mitigated when the specification includes firm fixed effects. Nevertheless, if there are time-varying omitted firm characteristics, such as future profit growth opportunities, that affect both the firm's incentives to invest in R&D and its cash holdings decisions, then the estimates would not have a causal interpretation. Our main contribution is to build on the existing evidence and identify the causal impact of innovation on cash by exploiting plausibly exogenous time-series variation in firms' incentives to innovate that arises due to changes in state R&D tax credits. Over time, state policy makers have used legislation and public subsidies to influence the costs of R&D, altering firms' incentives to make these investments. In this section, we use a standard difference-in differences approach and examine the impact of changes in state R&D tax credits on corporate cash policies.

3.1 Institutional Background

Most U.S. states offered an R&D tax credit as of December 2011. These state-level tax credits apply to R&D activities incurred within the state borders and are typically credits for the state corporate income tax.²⁶ The basic structure of the state credits is generally designed to mimic the federal R&D tax credit²⁷ and stipulates a statutory (percentage) tax credit rate for qualified research expenditures (QRE) incurred in the current year in excess of a base amount, which is typically a function of average QREs incurred in up to the prior three tax years. Most states use the federal definition of QRE from the Internal Revenue Code, Section 41,²⁸ with a modification to include only expenses incurred within

²⁶Only 3 states offer a sales tax credit. Firms are subject to state income taxes if they have an economic "nexus" with the state, which is generally determined based on whether they derive income from sales in the state, have employees or own lease property in the state (see Heider and Ljungqvist (2012) for additional details).

²⁷The federal R&D tax credit was introduced in 1981 and applies in addition to the state ones.

²⁸"Qualified research" is identified as research undertaken for the purpose of discovering information that is technological in nature and the application of which is intended to be useful in the development of a new or improved business component, as well as all of the activities of which constitute elements of a process of experimentation for a new or improved function, performance, reliability, or quality. There is also a list of research activities that do not qualify for the credit, such as computer software or social sciences. Finally, QREs are the amount paid for wages of employees engaging in qualified research, supplies used for qualified research, and 65 percent (higher for certain type of entities) of contract research expenses paid to outside entities to perform qualified research.

the state borders.²⁹ There is a lot of variation across states in the details of the definition of the base amount, but a feature that holds robustly across states is that the base definition is intended to capture R&D intensity of the firm based on prior-years' QREs.³⁰

Appendix B contains the full detailed list of state R&D tax credit changes, with their respective effective dates – i.e., the first year when the firm can claim the credit. For example, California increased its R&D tax credit from 12 percent to 15 percent (top statutory rate) effective from fiscal year 2000. In 2011, top statutory credit percentage rates ranged from 2 percent in Michigan to 100 percent for the "super" credit in Wisconsin, with 2 to 5 percent being relatively low credits rates, 15 to 20 percent being relatively high rates, and 10 percent being the most common rate.³¹ Over the last two decades, nearly every U.S. state has enacted some type of tax incentive for R&D and subsequently repealed, reduced, or expanded it.³² It is this variation over time that we exploit to generate exogenous variation in firms' incentives to innovate.

3.1.1 Intuition

In order to build intuition on how our identification strategy works, it is useful to consider how state R&D tax credits affect firms' decisions to invest in R&D. Following the standard approach in the economics of innovation literature (see, for example, Hall and Lerner (2010)), the standard benchmark to evaluate firms' R&D investment decisions is the 'neo-classical' marginal profit condition for optimal investment which is based on the original expression for the marginal cost or the so-called 'user cost' of physical capital of Hall and Jorgenson (1967)). Generalizing this expression, we can derive an expression for the firm (after-tax) marginal cost of R&D capital (per dollar of investment) as a function of the state R&D tax credit but also of all the other relevant economic and institutional determinants of R&D investment decisions.³³

²⁹Only five states (Colorado, Kentucky, New Hampshire, Washington, and West Virginia) depart from the federal QRE definition. Some are narrower; New Hampshire and Washington only include certain industries, while some are broader; West Virginia's statutory definition includes many expenses not eligible for the federal credit and Kentucky's credit applies to the costs of constructing, equipping, or expanding facilities used for R&D.

³⁰Eighteen states use the Federal Section 41 definition with an adjustment to apply to in-state expenses. Seven states use some form of a prior year(s) moving average base. Another alternative, used by four states (Alaska, Delaware, Nebraska, and New York), is to allow taxpayers to claim some percentage of their federal credit. Four states (Connecticut, Delaware, Oregon, and West Virginia) employ a dual base, where either different rates apply to two different base amounts or taxpayers can elect to claim the greater of two methods for computing the value of their credit. Finally, only two states (Kentucky and North Carolina) have non-incremental credits and consequentially do not define a base period.

³¹Some states offer tiered rates, with the percentage decreasing at some dollar amount of QRE.

³²Minnesota was the first state to enact a R&D tax incentive in 1981, followed by Indiana in 1984 and Iowa in 1985. All other states' credit enactments and changes are within our sample period.

³³For simplicity, here we abstract from the federal R&D tax credit, which would enter as an additional linear term at the numerator of our expression, thus leaving our main conclusions unchanged.

This derivation (see Appendix A in Hall and Van Reenen (2000) for full details) assumes that at time $t = 0$ the firm maximizes its market value, which is defined as the discounted present value of future dividends, with the discount factor implied by the real interest rate, r_t , and with the R&D capital stock defined using the same perpetual inventory method we used to define our empirical measure with depreciation rate δ . The resulting expression for firms' marginal cost of R&D investment is given by:

$$MP_{it}^{R\&D} = \frac{1 - \text{state statutory credit rate}_{it} \times f(R\&D_{it} - \text{base}(R\&D_{t-n})) - DA_{it}}{1 - \tau_{it}} [r_t + \delta]$$

where τ_{it} denotes the (effective) corporate income tax rate, DA_{it} is the NPV of depreciation allowances, and the effect of the state R&D tax credit is given by the product of the statutory credit rate and the part of R&D that qualifies for preferential tax treatment, which is given by the qualified R&D expenditures in excess of the base amount. It is immediate from this expression that $\frac{\partial MP_{it}^{R\&D}}{\partial \text{Credit Rate}} < 0$ - i.e., an increase (decrease) in the statutory R&D tax credit rate reduces (increases) the (after-tax) cost of an extra dollar invested in R&D. Thus, changes in state R&D tax credit rates are a plausible shock to firms' incentives to invest in R&D.

While parsimonious enough to derive transparent intuition for our identification strategy, this expression offers a relatively rich characterization of the determinants of the decision to invest in R&D. In particular, the following implications can be used to derive falsification tests for a sub-set of firms that are unlikely to be directly affected by the changes in tax credits:

Comparative static 1, variation with τ_{it} : $\frac{\partial^2 MP_{it}^{R\&D}}{\partial \text{Credit Rate} \partial \tau} < 0$ - i.e., any given increase (decrease) in the statutory R&D tax credit rate reduces (increases) the (after-tax) cost of an extra dollar invested in R&D by proportionally more in states with higher corporate income tax rates. Intuitively, since tax credits are generally not refundable, in any given year when the firm has no tax liabilities it cannot claim a credit. While the credit can be carried forward over the next years (generally up to 10), clearly credits have more bite in states with higher corporate profit taxes.

Comparative static 2, variation with $f(R\&D_{it} - \text{base}(R\&D_{t-n}))$: $\frac{\partial^2 MP_{it}^{R\&D}}{\partial \text{Credit Rate} \partial f(\cdot)} < 0$ - i.e., any given increase (decrease) in the statutory R&D tax credit rate reduces (increases) the (after-tax) cost of an extra dollar invested in R&D by proportionally more for firms that experience higher *growth* in R&D expenditures relative to their pre-treatment levels. Intuitively, this is the case since the base amount is an increasing function of past R&D intensity, which effectively operates as a 'claw-back' provision in terms of current tax credit. Thus, for any given amount of current R&D investment,

higher pre-treatment R&D expenditures reduce the effectiveness of tax credits.

3.2 Empirical Framework

To examine the effect of changes in state R&D tax credits on cash holdings, we use the following baseline difference-in-difference (DID) regression specification:

$$\begin{aligned} \Delta Cash_{ijst} = & \beta_1 \times \Delta RDTC_{st}^+ + \beta_2 \times \Delta RDTC_{st}^- \\ & + \delta_1 \times \Delta X_{it-1} + \delta_2 \times Cash_{ijst-1} + \alpha_{jt} + \varepsilon_{ijst} \end{aligned} \quad (1)$$

where i , j , s , and t index firms, industries, states, and years. Δ denotes the first-difference operator, $Cash$ is the ratio of cash holdings to book assets, $\Delta RDTC^+$ and $\Delta RDTC^-$ are indicators that equal one if any given state increases or cuts its R&D tax credit in any given year, respectively. The latter are contemporaneous changes, because our timing convention is to assign to each tax credit change its year effective – i.e., the first year when the firm can claim the credit, which is generally either the same year or the year subsequent the passage of the change. In addition to this baseline specification, we also estimate a more inclusive specification that adds leads and lags of the tax credit changes to examine the timing of the response of cash holdings.³⁴ X are firm-level controls for standard covariates of cash,³⁵ and α_{jt} are industry-year fixed effects. We evaluate statistical significance using robust clustered standard errors adjusted for non-independence of observations within firms.³⁶ The null hypothesis is that the coefficients of interest, β_1 and β_2 , which capture the effect of tax credit changes on cash holdings, are equal to zero.

The key identifying assumption behind our DID estimates, β_1 and β_2 , is that there are no systematic differences between treated and control firms that are relevant for their cash holding decisions. Our baseline specification rules out three main potential sources of such differences between treated and control firms: first, we control for unobserved, time-invariant heterogeneity across firms by estimating our DID regression in first differences; second, we control for unobserved, time-varying heterogeneity across industries ("industry shocks") by including industry-year fixed effects; and fi-

³⁴In additional robustness checks, we verified that our baseline estimates are robust to using a specification with only lagged changes in R&D tax credits (results available upon request).

³⁵Specifically, our baseline specification controls for cash flow volatility, market-to-book, firm size, cash flow, capital expenditures, (cash) acquisitions expenditures, and a dummy for whether the firm pays dividend.

³⁶In robustness analysis (Table 6, Panel A), we verify that the results are robust to adjusting the standard errors for clustering at the state level, to address the concern that the key source of variation in the analysis is at the state level (Bertrand, Duflo, and Mullainathan (2004)). This correction relaxes the assumption that firm observations are independent within each state.

nally, we control for firm level changes in performance or other determinants of cash holdings by including standard firm level determinants of cash. To minimize the risk of biases arising from the inclusion of potentially endogenous variables as per the "bad controls" problem discussed in Angrist and Pischke (2009), we include the pre-treatment (lagged) values of the firm-level variables.

The inclusion of an extensive set of controls for (observable and unobservable) potential confounds insures that our DID estimates are identified by comparing the differential (within-firm) response of cash holdings in the same industry-year for similar firms located in state-years when there is a change in the R&D tax credit (the 'treatment group') relative to those that are not (the 'control group'). Any residual threat to identification and to the internal validity of our baseline estimates can only come from residual unobserved, time-varying heterogeneity across states, such as, for example, state business cycle or political conditions or changes in other state taxes, that is not captured by the industry-year effects, which may bias our estimates if it coincides with changes in state R&D tax credits and is relevant for cash holding decisions.³⁷

Given the importance of these potential state-level confounds, we take several steps to address the issue: first, for our baseline estimates we take a conservative approach and only include in the treatment group changes in state R&D tax credits subsequent to their introduction, which, based on a probit analysis, appear not to be systematically related to (observable) state-wide confounds;³⁸ second, we implement falsification tests that exploit the institutional features of the R&D tax credit programs; third, we implement an extensive set of sensitivity tests, which include adding controls for potential state-level confounds; fourth, we refine the control group to include only firms in neighboring counties across border (see Homes (1998) for a similar approach) for which we can exploit the natural geographic discontinuity of tax policy (i.e., the fact that it stops at the state's border) together with the fact that these firms are likely to share common economic fundamentals to difference out unobserved variation in local economic conditions; and fifth, we replicate the DID tests after matching treated and control firms based on pre-treatment characteristics that include state business cycle conditions. This matched-sample DID estimator (Heckman, Ichimura, and Todd (1997)) further addresses the concern that differences between treated and control firms may invalidate our

³⁷The reason why this issue is a potential challenge for our identification strategy is that it potentially threatens our key identifying assumption of "parallel trends" by which we are effectively assuming that absent a change in the state R&D tax credit, treated firms' cash would have evolved in the same way as that of control firms. Thus, we need to address potential state level confounds that affect firms' demand for cash irrespective of the R&D tax credits' changes.

³⁸In robustness analysis (Table 5, Panel D), we assess the external validity of our baseline estimates by including also the introduction of state R&D tax credits in the treatment group.

parallel-trend assumption.³⁹

In robustness analysis, we also address potential concerns with the fact that our specification includes a lagged dependent variable, which controls for imperfections in cash rebalancing or partial adjustment in cash ratios (there is a vast literature on partial adjustment in leverage ratios – e.g., Lemmon, Roberts, and Zender (2008); see Dittmar and Duchin (2010) for recent evidence of partial adjustment for cash).⁴⁰ Allowing for partial adjustment of cash is important in light of the evidence on the persistent response of R&D to tax credits in the previous literature. The lagged dependent also controls for "Ashenfelter dip" type factors, that may be a concern in case the states are changing R&D tax credits in response to potentially unobserved factors related to firm cash holdings (Ashenfelter (1978)). Since OLS estimates of δ_2 may be biased in small- T unbalanced dynamic panels (Nickell (1981), Arellano and Bond (1991)), we do not emphasize this coefficient estimate and focus our discussion on the baseline estimates of the immediate impact of R&D tax credit changes or "short-term" elasticities, β_1 and β_2 . As a robustness test, however, we re-estimate specification (1) using a system IV-GMM estimator (Blundell and Bond (1998)),⁴¹ which is designed to address the econometric concerns associated with estimating dynamic panel data models in the presence of firm fixed effects.⁴²

Finally, in order to estimate (1), we remedy the measurement issue that Compustat's location information is often incorrect by hand-collecting historical headquarter states and zip codes for each firm-year in our sample from SEC filings. Compustat reports the current address of a firm's principal executive office, not its historic headquarter location, which is an issue since firms relocate their headquarters. Dealing with this issue is necessary since firms location information in our experiment is crucial to sort firms into the treatment vs. control groups, and incorrect location information is a source of measurement error that would likely bias our estimates in favor of a false null. For each fiscal year, we use a Perl program and, for each firm in our sample, search for location information in that year within the universe of its SEC filings (Def 14A, 10-Q, 10K).⁴³

As an additional data check on this procedure, we cross-check our hand-collected location infor-

³⁹We do not explore robustness to an alternative specification that would address potential confounds by including the mean of the group's dependent variable – i.e., mean cash holdings across firms in a given state-year – as a control, since it has been shown to lead to inconsistent estimates (Gormley and Matsa (2014)).

⁴⁰Allowing for partial adjustment is important also in light of the evidence that financial frictions lower the speed of adjustment of leverage and, thus, may be expected to also increase adjustment costs of cash (see Faulkender et al. (2012) for evidence on leverage).

⁴¹Specifically, the system IV-GMM approach includes lagged variable levels and differences in the instrument set to address the problem of persistent regressors, which, when differenced, contain little information for parameter identification.

⁴²In additional robustness checks, we verified that our baseline estimates are robust to using a specification that excludes the lagged dependent variable (results available upon request).

⁴³We retrieve the bulk of the proxy filings from the Compact Disclosure disks until they are available (2005) and supplement them with filings from Edgar Online whenever not available.

mation with historical event information from Capital IQ Key Developments database, which tracks headquarter relocation announcements starting from 2001.⁴⁴ We find a high degree of overlap between location information from Capital IQ and the one we retrieved manually, with our procedure "missing" location changes in Capital IQ for less than 1/2% of firm-years observations in the sample.⁴⁵ By contrast, Compustat state information is incorrect in 11.5% of the firm-years observations, affecting 17.1% of innovative firms in the sample.

3.2.1 Validation of R&D Tax Credit Changes: Do They Coincide with Other State-Level Changes that are Potentially Relevant for Cash? And, Do They Matter for Innovation?

For our baseline DID estimates to be well-identified, the key assumption of parallel-trends between treated and control firms has to be valid, because it is under this assumption that we can be assured that absent any R&D tax credit changes, treated firms' cash holdings would have evolved in the same way as that of control firms. In addition, changes in state R&D tax credits must be effectively "innovation shocks," because if they did not matter for innovation, that would cast doubt on the interpretation of our coefficient estimates on changes in R&D tax credits as reflective of the impact of innovation on cash. In order to offer a screening of the internal validity of our estimates, we examine these two issues in turn.

First, we implement validation tests of the main residual identification concern about our baseline estimates. As we have emphasized in the description of our baseline specification, potential identification concerns can only arise because of residual, time-varying heterogeneity across states that is not captured by the industry-year effects, which may bias our estimates if it coincides with changes in state R&D tax credits and is relevant for cash holding decisions. Thus, we examine the determinants of states' likelihood of changing their R&D tax credits, which we allow to be a function of state-level variables that, on an a-priori basis, we expect may be relevant for cash holding decisions. These variables include proxies for state business cycle conditions, since there is evidence that firm financial policies (Korajczyk and Levy (2003)) and cash holdings (Eisfeldt and Muir (2013), Warusawitharan

⁴⁴Capital IQ Key Developments database consists of information gathered from a wide variety of sources, including public news, company press releases, regulatory filings, call transcripts, investor presentations, stock exchanges, regulatory and company websites. Capital IQ analysts filter the data, link it to standard company identifiers (gvkey), and then categorize it based on the type of event involved. We retain only the "Address Change" announcement category, which contains about 1,500 announcements involving Compustat firms in the 2001-2011 period.

⁴⁵We looked up a handful of such cases, and they all corresponded to address changes that were announced (and, as such, recorded in the Capital IQ database), but not completed. Thus, we opted for keeping our location information in the few instances when Capital IQ records a relocation announcement that is not recorded in the regulatory filings. In additional robustness tests (available upon request), we verified that our results are little changed if we alternatively use the Capital IQ location information in these cases.

and Whited (2013)) are responsive to the business cycle; for political and labor market forces, since there is evidence that political uncertainty heightens firms' precautionary motive (Baker, Bloom, and Davis (2013)) and that bargaining with unions matters for leverage (Matsa (2010)) and cash (Schmalz (2013)); and for other taxes, since, for example, corporate taxes could have an independent effect on cash for reasons related to the tax benefits of debt (see Heider and Ljungqvist (2012) for evidence on corporate taxes and leverage).

The results of this first set of validation tests are reported in Panel A of Table 3, which tabulates estimates from linear-probability regression analysis of the likelihood that a state changes its R&D tax credit in a given year for different types of changes in turn: tax credit introduction or subsequent increases (Column 1), introduction only (Column 2), increases subsequent to introduction (Column 3), and cuts subsequent to introduction (Column 4). The introduction of R&D tax credits is the only type of change that is systematically related to state economic conditions and, in general, to state-level variables, with the Wald test unable to reject the null that these variables are jointly insignificant at the 5% confidence level. By contrast, increases or cuts of R&D tax credits subsequent to their introduction appear generally unresponsive to economic conditions and unrelated to other state-level variables. In addition, as shown in Figure 1, the time-series of these subsequent changes is indeed staggered over time by state and their geographic distribution is fairly spread out across the U.S. map. Based on these results, we take a conservative approach and for our baseline estimates only include in the treatment group changes in state R&D tax credits subsequent to their introduction. Since we recognize that tax credit introductions, though less suitable for standard DID research design, are potentially interesting discrete events, we examine their impact in an extensive set of dedicated robustness tests.

As a second validation test of our quasi-experimental setting, Panel B of Table 3 reports parameter estimates from DID regressions of changes in innovation on changes in state R&D tax credits. Column 1 refers to R&D expenditures and Column 2 to R&D capital, while, for the sake of falsification, Column 3 refers to Capex and Column 4 to property, plants, and equipment (PPE).⁴⁶ The estimates show that, on average and relative to other firms in the same industry that are not subject to R&D tax credit changes in their headquarter state-year, there is a strongly statistically significant 0.3% (0.2%) increase (decrease) in R&D expenditures following R&D tax credit increases (cuts). These effects are economically significant, at about 10% of their average pre-treatment levels.⁴⁷ The impact on R&D

⁴⁶All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

⁴⁷As shown in Table 1, average R&D expenditures in the innovative firms sample are 3% of book assets.

capital is even larger, with an 8.8% (7.4%) increase (decrease), which are about 1/4 of their average levels in the sample. Capex and PPE show no significant response. These findings confirm the existing evidence that R&D expenses respond strongly to tax incentives and their impact is long-lived (see Hall and Van Reenen (2000) for a survey).

By way of summary of the existing evidence on the effectiveness of R&D tax credit, previous studies find a considerable response of R&D to tax credits in the U.S. For example, several studies show evidence that the federal R&D tax credit introduced in 1981 produced roughly a dollar-for-dollar increase in R&D investment (Hall (1992), Berger (1993), and Hines (1993)). Another main finding is that the R&D response tends to increase over time and is ultimately sizable in the long term. Wilson (2009) documents roughly similar estimates for R&D tax credits at the state rather than at the federal level. There is also growing evidence from cross-country studies that supports the overall effectiveness of tax credits at stimulating R&D, though point estimates differ depending on the specific country and period, the type of R&D tax credit, as well as the specifics of its implementation. For example, Bloom, Griffith, and Van Reenen (2002) document evidence of tax credits leading to a dollar-for-dollar increase in R&D investment for a panel of nine OECD countries over the 1979 to 1997 period. In a recent study, Mulkay and Mairesse (2013) document a bit smaller (three quarters of a dollar-for-dollar increase), but still overall large and reliably significant estimates of the effect of the 2008 R&D tax credit in France.

3.3 Baseline DID Estimates

Our baseline estimates from DID regressions of changes in cash holdings on changes in state R&D tax credits for several different specifications and definitions of cash ratios are reported in Table 4.⁴⁸ Columns 1 to 3 report results for cash to book asset ratios, in turn for the baseline specification (1), as well as for a more inclusive specification with leads and lags of R&D tax credit changes to address pre-trends, and for a specification where the percentage change in the R&D tax credit is used instead of an indicator variable to examine the question of whether the size of the R&D tax credits matters. Robustly across these specifications, the estimates indicate that after states change their tax codes to increase (decrease) R&D tax credits, firms increase (decrease) their cash holdings relative to otherwise similar firms in the same industry that are not subject to R&D tax credit changes in their headquarter state-year. The baseline estimates in Column 1 show that there is an increase (decrease) in cash to

⁴⁸All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

book assets of about 2 (1.7) percentage points after an increase (decrease) in R&D tax credits. These effects are economically significant, at about 9% (7%) of their average pre-treatment levels.⁴⁹ The lack of significance and the relatively small size of the estimates for leads and lags indicate that there is no evidence of either firm anticipation or pre-event trends. Finally, larger tax credit changes trigger larger responses in cash holdings.

Nonparametric analysis of average annual within-firm changes in cash to book asset ratios in event time leading to and after the year when a state increases (Panel A of Figure 1) or cuts (Panel B of Figure 1) its R&D tax credit confirms that there is a sharp and statistically significant change in cash holdings in the year of treatment ($t = 0$), which is not reversed in subsequent years.⁵⁰ The remaining columns of Table 4 report DID estimates for the baseline specification using alternative definitions of cash ratios, with the goal of addressing measurement issues with our dependent variable. We experiment with several alternative definitions of cash ratios, which include cash to book assets net of cash (Column 4) and cash to market value of assets (Column 5), which address the concern that changes in the denominator of our dependent variable may be driving the result, as well as with cash minus net income to book assets (Column 6) and cash to lagged cash plus net income (Column 7). These latter measures, either by netting income out of cash or by considering the marginal propensity to retain cash out of cash flow, address the concern that we may be hard-wiring the result if cash changes are simply due to mechanical retention of, say, potentially higher realizations of after-tax cash flows due to firms cashing in on higher R&D tax credits. The results are remarkably stable across all of these measures, indicating that changes in firm cash holding decisions (the numerator) are driving the baseline estimates and that these changes are not purely driven by mechanical retention.

3.3.1 Falsification Tests

Are our baseline DID estimates well-identified? We address this question with two batteries of falsification tests.⁵¹ First, we repeat our analysis of changes in cash holdings to book assets after changes in state R&D tax credits for two different sub-sample splits of the data based on proxies for the in-

⁴⁹Specifically, as shown in Table 1, the average cash to book asset ratio in the innovative firms sample is 24%. Thus, our baseline DID estimate is about 9% of the sample mean ($0.021/0.24=0.0875$) for R&D tax credit increases and about 7% of the sample mean ($-0.017/0.24=0.071$) for R&D tax credit cuts.

⁵⁰Plotted changes are in excess of contemporaneous cash changes in the firm's 48-FF industry, to remove the influence of time-varying changes in industry conditions, and of predicted changes based on pre-treatment cash levels, to control for partial adjustment of cash. In the years prior to treatment ($t = -2, -1$), cash changes are close to zero on average, confirming the regression result that there is no evidence of pre-event differential trends between treated and control firms.

⁵¹The specifications for both tests are all estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

stitutional features of the R&D tax credits that should affect their effectiveness. The intuition behind these falsification tests is to exploit the non-linearities from the comparative static properties of the opportunity-cost of R&D that we derived above from the institutional design of the state R&D tax credit programs. If cash holdings are responding to unobserved factors, such as changes in local conditions (orthogonal to our state-level controls) rather than to R&D tax credit changes, then we should see no variation across groups when we split the sample by proxies for the intensity of the treatment. The estimate, which are presented in Columns 1 to 4 of Table 5, show a starkly different pattern. Robustly across either of our two sample splits, there are strong and significant effects for firms that are subject to a stronger treatment, which are proxied by above median (year-prior) values of state corporate tax rate (Column 1) and of growth in firm R&D expenditures with respect to their pre-treatment level (Column 3). By contrast, the effects are weak and not statistically significant for firms that unlikely to be affected by the tax credit based on either metric (Columns 2 and 4).

Second, we implement another set of falsification tests that exploits state tax credits for a different type of investment. Specifically, we consider the response of cash to changes in state investment tax credits, which are state-level tax incentives programs otherwise analogous to the R&D tax credits except for the fact that they give tax relief for capex – i.e., for investment in PPE, such as plants, machinery, and buildings. Chirinko and Wilson (2008) hand-collected state-level data on these programs and show evidence of their effectiveness at stimulating physical capital expenditures. We use their data to construct indicator variables for changes in state investment tax credits, which consist of 18 introduction events, 27 increases, and 8 cuts.⁵² If our estimates are simply picking up either mechanic retention from cashing in on tax incentives or unobserved state-wide factors, then the nature of the tax incentives should not matter and we should expect a response of cash to changes in investment tax credits that is qualitatively similar to the one we documented for R&D tax credits. However, this is not what the estimates presented in Columns 5 to 6 of Table 5 indicate: the response of cash to changes in investment tax credits, though somewhat weaker in magnitude, is qualitatively the exact opposite of the response to R&D credits, with cash decreasing (increasing) in response to increases (cuts) in investment tax credits.

In addition to offering a useful falsification test, the evidence of a differential response of cash to tax credits for R&D versus investment in physical assets supports theories of cash based on debt financing frictions such as Rampini and Viswanathan (2010) and Falato, Kadyrzhanova and Sim (2013),

⁵²We refer the reader to Chirinko and Wilson (2008) for further details on this data.

since cash is accumulated in response to higher incentives to invest in intangible assets that cannot be easily financed with debt due to the lack of pledgeability of these assets. Thus, while both state tax credits for capital expenditures and those for R&D constitute incentives for higher investment, only R&D tax credits lead to cash accumulation, which is consistent with the notion that debt is relatively more suitable to finance capital expenditures. In the next section, we will return to the question of debt financing frictions and offer additional, more direct evidence on their role in our analysis of the channels through which innovation impacts cash.

3.3.2 Robustness and External Validity Tests

Next, we run a battery of sensitivity tests to further corroborate the internal validity of our baseline estimates. Table 6 tabulates the results. We consider three different sets of sensitivity tests.⁵³ First, we estimate versions of our baseline DID regressions that use alternative standard errors and add more firm-, state-, and industry-level control variables (Panels A and B). Row 1 shows results for a specification that clusters standard errors at the state level, to address the concern that the key source of variation in the analysis is at the state level (Bertrand, Duflo, and Mullainathan (2004)), and adds state fixed effects to control for unobserved time-invariant differences among states, so that the resulting estimates are identified using within-firm, within-industry-year, and within-state variation. Rows 2 to 8 add controls for firm- and industry-level, as well as time-varying state-level confounds.

Second, we address the concern that local economic conditions could contaminate our inference by refining our control group (Panel C, Row 9). Specifically, we refine the control group to include only firms in neighboring counties across border (see Homes (1998) for a similar approach). The intuition for why this approach is effective at differencing out local economic conditions is that tax policies display a natural geographic discontinuity at the border (i.e., they stop at the state's border), while other spurious factors such as local economic conditions plausibly do not. Thus, by comparing neighboring county pairs across state borders, we can difference out unobserved variation in local economic conditions. We do so by estimating a version of our baseline specification that adds county-pairs fixed effects and is estimated only for firms that have a neighboring county across the border. The resulting estimates are identified within contiguous county dyads across state borders, which sharpens our identification. Overall, our DID estimates are stable across these two sets of sensitivity tests.

⁵³All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

Third, we consider robustness to alternative estimators and assess the external validity of our baseline estimates. We consider three alternative estimators: the system IV-GMM of Blundell and Bond (1998) to address potential biases from including the lagged dependent variable (Panel C, Row 10); an IV-DID (2-SLS) estimator that uses R&D tax credit changes as instruments for changes in R&D capital, to offer well-identified estimates of the impact of R&D on cash (see Bloom, Schankerman, and Van Reenen (2013) for a similar approach; estimates of the second stage regression with instrumented R&D stock are reported in Panel C, Row 11); and a matched-sample DID estimator (Heckman, Ichimura, and Todd (1997)) that matches treated and control firms based on pre-treatment size, industry, and performance to address the concern that these differences between treated and control firms may invalidate our parallel-trend assumption.

To examine external validity, we include R&D tax credit introduction events (Panel D, Rows 13 and 15) and a subset of the most discrete such events (top quartile of the statutory credit rate; Panel D, Rows 14 and 16) in the treatment group. Given our finding that tax credit introductions are systematically related to state economic conditions, for both cases we report matched-sample DID estimates based on pre-treatment state economic conditions.⁵⁴ Our estimates remain stable across different estimators and types of treatments. Overall, results of the falsification, sensitivity, and external validity tests support a causal interpretation of the observed response of cash.

4 Why Does Innovation Matter? Assessing the Channels

In the second part of our analysis, we investigate the drivers of the treatment effect by examining its variation with several variables that, based on theory, we expect should affect the demand for cash by innovative firms. We test whether the treatment effect displays systematic heterogeneity across four set of variables that capture the main theories summarized in our theory overview section: financing frictions, agency frictions, repatriation, product market competition. We also offer a direct assessment of financing frictions by examining the impact of changes in state R&D tax credits on firms' liquidity structure (cash vs. lines of credit), as well as debt and equity financing decisions. This analysis provides an empirical assessment of the different explanations for why innovation has an impact on cash. In addition, it offers evidence on the determinants of cash holding and, more broadly, financing decisions for innovative firms.

⁵⁴While we report vanilla DID estimates for reference in Rows 13 and 14, we emphasize that they are best interpreted as descriptive evidence.

4.1 Assessing Debt & Equity Financing Frictions

If innovative firms hold more cash because of financing frictions, then the treatment effect of state R&D tax credits on cash should be stronger among firms that face more severe financing frictions. Table 7 reports results from running our baseline DID regressions in several different sub-sample splits of the data based on broad ex-ante proxies for the severity of financial frictions faced by firms (Panel A), as well as for the intensity of the precautionary motive to hold cash (Panel B), an approach which is standard in the literature (e.g., Hennessy and Whited (2007)).⁵⁵ Specifically, we split the sample between above vs. below median (pre-treatment) values of the following variables: firm size (Column 1), Kaplan and Zingales (1997) KZ-Index (Column 3), Whited and Wu (2006) WW-Index (Column 4), firm cash flows (Column 5), firm age (Column 6), firm market-to-book ratio (Column 7), firm cash flow volatility (Column 8), and by dividend payer status (Column 2). Robustly across these proxies, the results indicate that the response of cash to changes in state R&D tax credits is magnified by firms' financing constraint status, with firms that have greater financial slack showing a muted response, and by the intensity of their precautionary motive, with the effect concentrated among relatively younger and riskier firms, those with low cash flows and greater growth potential.

Next, we examine which financing frictions matter. To assess debt financing frictions, we take two different approaches, with results summarized in Table 8. First, we examine the impact of changes in state R&D tax credits on corporate liquidity structure and debt financing (Panel A). We consider probit regressions of the likelihood of having bank liquidity (Column 1), DID estimates of changes in unused bank liquidity (unused lines of credit) to total liquidity (Column 2), in net debt issuance (Column 3), and in net book leverage (Column 4), and estimates from probit regressions of the likelihood of having a debt structure that is specialized in bank debt (Column 5) and in secured debt (Column 6). In all these tests, we use a specification analogous to our baseline (1). Second, we run our baseline DID regressions of cash holdings for three different sub-sample splits of the data based on ex-ante proxies for the severity of the debt financing frictions faced by firms (Panel B): Berger et al. (1996) asset liquidation value (Columns 1 and 2), Balasubramanian and Sivadasan (2009) index of industry asset redeployability (Columns 3 and 4), and based on whether the firm has a long-term debt rating (Columns 5 and 6). Increases (cuts) in R&D tax credits lead to increases (decreases) in cash relative to bank lines of credit, and to decreases (increases, though estimates of these increases are noisy) in

⁵⁵All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

bank debt, secured debt, and overall net indebtedness. These results, together with the evidence that R&D tax credits have a stronger impact on cash for firms that have relatively less access to debt financing, are all consistent with a debt financing channel through which innovation increases firms' demand for cash by reducing their debt capacity.

We follow an analogous strategy to assess equity financing frictions. The results are summarized in Table 9, which reports parameter estimates of the impact of changes in state R&D tax credits on equity financing (Panel A), and DID estimates of our baseline cash regressions for several different sub-sample splits of the data based on ex-ante proxies for the severity of the equity financing frictions faced by firms (Panel B). Specifically, in Panel A we report DID estimates of changes in net equity issuance (Column 1) and cash to book equity ratio (Column 3), and estimates from probit regressions of the likelihood of a secondary equity issue (SEO) (Column 2). In Panel B, the sample is split based on the total dollar volume of SEOs in a firm's (48-FF) industry in any given year (Columns 1 and 2), the average (0, +1) cumulative abnormal return (CAR) of SEOs announcements in a firm's (48-FF) industry in any given year (Columns 3 and 4), which are commonly employed proxies for hot vs. cold equity markets (e.g., Korajczyk and Levy (2003), and the standard deviation (dispersion) of analysts' EPS forecasts from IBES (Columns 5 and 6).

Table 9 shows that increases (cuts) in R&D tax credits lead to increases (decreases) in net equity issuance. However, cash increases also relative to book equity, suggesting that, even though innovative firms are well-recognized to be relatively more reliant on equity, external financing is only an imperfect substitute for internal funds. Also consistent with an equity financing channel, R&D tax credits have a stronger impact on cash at times when firms have relatively less access to equity markets. In all, this evidence indicates that external financing frictions are an empirically relevant explanation for why innovative firms holds more cash, and that this is due not only to debt financing frictions, which have been the traditional focus of the existing literature surveyed in Hall and Lerner (2010) (see Chava et al. (2013) and Mann (2013) for recent studies), but also to equity financing frictions, whose importance has been recently emphasized by dynamic corporate finance models such as Bolton, Chen, and Wang (2011), Eisfeldt and Muir (2013), and Warusawitharan and Whited (2013) (see Brown, Martinsson, and Petersen (2013) for recent cross-country evidence on the importance of equity frictions for R&D financing).

4.2 Assessing Repatriation, Industry Competition, and Agency

In our final set of tests, we run our baseline DID regressions of cash holdings for three types of sub-sample splits of the data based on ex-ante proxies for repatriation incentives and product market competition (Panel A of Table 10), as well as of the severity of agency frictions faced by the firm (Panel B of Table 10).⁵⁶ In Panel A, the sample is split between above vs. below median (pre-treatment) values of the foreign tax burden measure of Foley, Hartzell, and Titman (2007) (Columns 1 and 2), based on whether the firm reports foreign income in a given year (Columns 3 and 4), and based on above vs. below median (pre-treatment) values of the (48-FF) industry Herfindahl-Hirschman Index (HHI) of sales (Columns 5 and 6). The results indicate that the response of cash to changes in state R&D tax credits is weakened by firms' multinational status, suggesting that the positive effect of innovation on domestic financing frictions is empirically the driving factor of the repatriation channel, while the response is magnified by the intensity of industry competition, which supports recent theories such as Morellec, Nikolov, and Zucchi (2013) and Ma, Mello, and Wu (2013) where cash holdings strengthen the competitive position of firms vis a vis their industry rivals.

In Panel B of Table 10, we examine the agency channel. We report results for the sub-sample of firms in relatively concentrated industries (those with above-median HHI) and further stratify the sample based on above vs. below median (pre-treatment) values of standard metrics for the likelihood of managerial entrenchment, which include board size (Columns 1 and 2), board independence (Columns 5 and 6), and whether the firm has a classified board of directors (Columns 3 and 4). Robustly across these metrics, the results indicate that R&D tax credits have a stronger impact on cash for firms that are relatively more likely to face agency issues between managers and shareholders. By contrast, when we replicate these agency splits either in the overall sample or in the sub-sample of firms in relatively less concentrated industries (those with below-median HHI), we find mixed results.⁵⁷ This evidence is consistent with the view that there is no "one size fits all" governance for innovative firms that face intense competitive pressure (Coles, Daniel, and Naveen (2008)). By contrast, and in line with the findings of significant interaction effects between governance and industry (Giroud and Mueller (2011)), in relatively less competitive industries classical agency considerations of the type highlighted in the empirical literature by Dittmar and Mahrt-Smith (2007) and Gao, Harford, and Li (2013) are likely to be important factors for innovative firms.

⁵⁶All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included.

⁵⁷Which we do not report for brevity.

5 Conclusions

Does innovation matter for corporate cash holdings, and why? That innovation *should* matter for a variety of explanations, including financing frictions, agency problems, product market competition, and repatriation is well-understood. Yet, it is challenging to provide well-identified estimates of the impact of innovation on cash and to understand which explanations are empirically relevant. One big challenge is that commonly-employed variables associated with innovation, such as R&D expenditures or capital, are also related to future business opportunities, which complicates a causal interpretation of existing cross-sectional evidence. In an attempt to advance the empirical literature on this important yet challenging question, we have exploited time-series variation in firms' incentives to innovate around changes in state R&D tax credits.

In particular, we have taken several steps to design a quasi-natural experimental setting that is successful at overcoming the empirical identification challenge of finding plausibly exogenous sources of variation in the innovation-driven demand for cash. We have used our quasi-experimental setting to assess specific channels through which innovation matters. Our evidence indicates that innovation is a first-order determinant of corporate liquidity, and clarifies when innovation matters in the cross-section. Specifically, innovation matters not only for cash holding decisions of firms that face more severe debt financing frictions, but also at times when firms have less access to equity financing. In addition, it matters more in relatively more competitive industries. Finally, we also find evidence supporting the importance of agency issues for innovative firms, which matter empirically but only in relatively less competitive industries.

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Appendix A. Variable Definitions

The variables used in the analysis are defined as follows, with their respective data sources:

Corporate Liquidity Variables:

- Cash to Book Assets is defined as cash and marketable securities (Compustat data item #1) divided by book assets (#6).
- Cash to Net Book Assets is cash and marketable securities (#1) divided by book assets (#6) minus cash and marketable securities (#1).
- Cash to Market Value of Assets is cash and marketable securities (#1) divided by long-term debt (#9) plus debt in current liabilities (#34) plus market value of equity, which is constructed as common shares outstanding (#25)*price (#199).
- Cash to Book Equity is cash and marketable securities (#1) divided by book equity, which is defined as book value of common equity (#60) plus preferred stock (#10).
- Net Cash to Book Assets is cash and marketable securities (#1) minus net income (#172) divided by book assets (#6).
- Dollar Cash is cash and marketable securities (#1) in 1990 dollars (using CPI).
- Bank Liquidity to Total Liquidity is the ratio of total line of credit (drawn plus undrawn, Capital IQ data) to the sum of total line of credit (drawn and undrawn, Capital IQ data) plus cash and marketable securities (#1).
- Unused Bank Liquidity to Total Liquidity is the ratio of unused line of credit (undrawn, Capital IQ data) to the sum of unused line of credit (undrawn, Capital IQ data) plus cash and marketable securities (#1).

Innovation & State R&D Tax Credits:

- R&D Expenditures is the ratio of R&D expenditures (#46) to book assets (#6).
- R&D Capital is constructed by capitalizing R&D expenditures using the perpetual inventory method as follows: $G_{it} = (1 - \delta_{R\&D}) G_{it-1} + R\&D_{it}$ where G_t is the end-of-period stock of R&D capital, $R\&D_{it}$ is the (\$1990 real) expenditures on R&D during the year, and $\delta_{R\&D} = 15\%$ following Hall, Jaffe, and Trachtenberg (2001). If R&D expenditures are constant (in real terms), the stock of R&D capital is $G_t = \sum_{s=0}^{\infty} (1 - \delta)^s R\&D_{t-s} = \frac{R}{\delta}$. We set the initial stock to be equal to the R&D expenditures in the first year divided by the depreciation rate $\delta_{R\&D}$. In addition, we interpolate missing values of R&D following Hall (1993) who shows that this results in an unbiased measure of R&D capital. The R&D stock is scaled by (\$1990 real) book assets (#6).
- R&D Tax Credit Increase is a dummy variable that equals one if a state either increases or re-introduces its R&D tax credit in a given year. Details on data sources and the full list of events are in Appendix B.
- R&D Tax Credit Cut is a dummy variable that equals one if a state either cuts its R&D tax credit or lets it expire in a given year. Details on data sources and the full list of events are in Appendix B.
- R&D Tax Credit Introduction is a dummy variable that equals one if a state that never had an R&D tax credit introduces it in a given year. Details on data sources and the full list of events are in Appendix B.

Baseline Firm Controls:

- Cash Flow Volatility is the standard deviation of cash flow to book assets. Standard deviation of cash flow to book assets is computed for every firm-year using data over the previous ten years.
- Market-to-Book ratio is the ratio of the book value of assets (#6) minus the book value of equity (#60) plus the market value of equity (#199 * #25) to the book value of assets (#6).
- Firm Size is the natural logarithm of book assets (#6) in 1990 dollars (using CPI).
- Cash Flow is earnings after interest, dividends, and taxes before depreciation divided by book assets ((#13 - #15 - #16 - #21) / #6).

- Capital Expenditures is the ratio of capital expenditures (#128) to book assets (#6).
- Dividend is a dummy variable equal to one in years in which a firm pays a common dividend (#21). Otherwise, the dummy equals zero.
- Acquisition Expenditures is the ratio of acquisitions (#129) to book assets (#6).

Channels & Additional Controls:

Debt & Equity Financing Channels:

- Net-Leverage is the ratio of long-term debt (#9) plus debt in current liabilities (#34) minus cash and marketable securities (data item #1) to book assets (#6).
- Leverage is the ratio of long-term debt (#9) plus debt in current liabilities (#34) to book assets (#6).
- Bank Debt to Total Debt is the ratio of total bank debt (line of credit plus term loan, Capital IQ data) to total debt (Capital IQ data).
- Bank90 is a dummy that takes value of one for firm-year observations that are in the top decile of the distribution of bank debt to total debt (Capital IQ data).
- Secured Debt to Total Debt is the ratio of total secured debt (Capital IQ data) to total debt (Capital IQ data).
- Secured90 is a dummy that takes value of one for firm-year observations that are in the top decile of the distribution of secured debt to total debt (Capital IQ data).
- Net Debt Issuance is long term issuance (#111) minus long term debt reduction (#114) plus changes in current debt (#301), divided by book assets.
- Net Equity Issuance is Sale of Common and Preferred Stock (#108) minus purchase of common and preferred stock (#115), divided by book assets.
- SEO Volume is the total dollar value of SEOs in a firm's (48-FF) industry in a given year, and is constructed from the database of 4,291 SEOs of Loughran and Ritter (1995) (as updated by the authors) for the 1973-2001 period, and from SDC for the 2002-2011 period.
- SEO Costs is the average (0, +1) cumulative abnormal return (CAR) of SEOs announcements in a firm's (48-FF) industry in a given year, and is constructed from the database of 4,291 SEOs of Loughran and Ritter (1995) (as updated by the authors) for the 1973-2001 period, and from SDC for the 2002-2011 period.
- Analyst Forecast Dispersion is the standard deviation of analysts' EPS forecasts (IBES data).
- KZ-Index is based on Kaplan and Zingales (1997) and is as follows:

$$KZ = -1.002 * \text{Cash flow} + 0.283 * Q + 3.139 * \text{Leverage} - 39.368 * \text{Dividends} - 1.315 * \text{Cash},$$
 where Q is the market-to-book ratio, Dividends is the ratio of total dividends to book assets, and the other variables are as defined above.
- WW-Index is based on Whited and Wu (2006) and is as follows:

$$WW = -0.091 * \text{CashFlow} - 0.062 * \text{Dividend} + 0.021 * \text{Leverage} - 0.044 * \text{Size} + 0.102 * \text{Industry Growth} - 0.035 * \text{Growth},$$
 where Industry Growth is the 4-SIC industry sales growth, Growth is own-firm real sales growth, and the other variables are as defined above.
- Resale Value is based on Berger et al. (1996) and is the sum of $0.715 * \text{Receivables} (\#2)$, $0.547 * \text{Inventory} (\#3)$, and $0.535 * \text{Capital} (\#8)$.
- Asset Redeployability Index is based on Balasubramanian and Sivadasan (2009) and is the fraction of total capital expenditures in an industry accounted for by purchases of used (as opposed to new) capital, computed at 4-digit SIC level and constructed using hand-collected US Census Bureau data. Since these data are available only once every 5 years and not for more recent years, we compute a time-invariant index by averaging the available quinquennial indexes at the 4-SIC level. This measure is only available for a restricted sample of manufacturing firms.

- Firm Age is the number of years since IPO, with information on IPO year gathered from Compustat, when available, and otherwise from SDC and Jay Ritter's IPO database.
- Debt Rating is a dummy that equals one if the firm has a debt rating from S&P in a given year, and is constructed based on Compustat historical debt rating information.

Agency, Product Market, and Repatriation Channels:

- Marginal Tax Rate is the after-interest marginal tax rate from Graham (1996).
- Foreign Tax Burden is constructed following Foley, Hartzell, Titman, and Twite (2007) as the maximum between zero and foreign pre-tax income (#273) times the marginal tax rate minus foreign taxes paid (#64).
- Foreign Income is the ratio of foreign pre-tax income (#273) to book assets (#6).
- Industry Competition is the Herfindahl-Hirschman Index (HHI), which is constructed as the sum of the squares of the individual company market shares for all the firms in a given (48-FF) industry-year.
- High-Tech industries are defined following Loughran and Ritter (2004) as SIC codes 3571, 3572, 3575, 3577, 3578, 3661, 3663, 3669, 3674, 3812, 3823, 3825, 3826, 3827, 3829, 3841, 3845, 4812, 4813, 4899, 7370, 7371, 7372, 7373, 7374, 7375, 7378, and 7379.
- Board Size is the total number of directors on the board in a given firm-year, and is constructed using information from proxy filings extracted from Compact Disclosure for the 1986-2005 period (as in Linck, Netter and Yang (2008)), and using Capital IQ for the 2006-2011 period.
- Classified Board is a dummy variable that equals one if the firm has a classified board of directors, and is constructed using IRRC data for the 1992-2005 period, and Capital IQ for the 2006-2011 period.
- Board Independence is the ratio of the number of non-executive directors to the overall number of directors in a given firm-year, and is constructed using information from proxy filings extracted from Compact Disclosure for the 1986-2005 period (as in Linck, Netter and Yang (2008)), and using Capital IQ for the 2006-2011 period.

Additional State Controls:

- State GDP growth is the real annual growth rate in gross state product (GSP), from BEA data.
- State Unemployment Rate is the state unemployment rate, from BLS data.
- Vote Share of Republican Presidential Candidate is the state's share of the vote cast for the Republican candidate in the last presidential election, from the data of the American Presidency Project at UC Santa Barbara.
- Union Membership is the fraction of private-sector employees who belong to a labor union in a state-year, from the Hirsch and Macpherson (2003) data base.
- Change in Corporate Taxes is a categorical variable that equals one if a state increases its corporate tax rate in a given year, and minus one if a state cuts its corporate tax rate in a given year. Data is from Appendix A and Appendix B of Heider and Ljungqvist (2012).
- Change in Personal Income Taxes is a categorical variable that equals one if a state increases its personal income tax rate in a given year, and minus one if a state cuts its personal income tax rate in a given year. The personal income tax rate is the maximum state tax rate on wage income, from the NBER Taxsim data.
- State Investment Tax Credit Introductions is a dummy variable that takes the value of one if a state that never had an investment tax credit introduces it in a given year, and is from the data base hand-collected by Chirinko and Wilson (2008) and therein detailed.
- State Investment Tax Credit Increases (Cuts) is a dummy variable that takes the value of one if a state increases (cuts) its investment tax credit in a given year, and is from the data base hand-collected by Chirinko and Wilson (2008) and therein detailed.

Appendix B. List of Changes in State Tax Credits

This table details all the 73 state R&D tax credits' changes (35 introductions and 38 subsequent changes, of which 24 are increases and 14 are cuts) between tax years 1987-2011 used in the DID analysis. We hand-collected this information for all U.S. states using a variety of sources. The State Tax Handbook (various years) and Wilson (2009) provided the starting point to get a summary list of R&D tax credits available in any given state at a particular point in time. We then cross-checked this information by verifying the passage of state tax bills and obtaining information on the year when a given tax credit becomes effective through keyword searches in Lexis-Nexis (State Net) and online searches of state code legislation and tax forms on the states' Department of Revenue websites.

Year Effective	State	Description
1987	Minnesota	Cuts R&D tax credit from 6.25% to 2.5%
1988	California	Introduces a tax credit of 8% of qualified incremental R&D expenditures
1988	Kansas	Introduces a tax credit of 6.5% of qualified incremental R&D expenditures
1988	North Dakota	Introduces a tax credit of 4% of qualified incremental R&D expenditures
1989	Colorado	Introduces a tax credit of 3% of qualified incremental R&D expenditures
1989	Oregon	Introduces a tax credit of 5% of qualified incremental R&D expenditures
1990	Illinois	Introduces a tax credit of 6.5% of qualified incremental R&D expenditures
1991	Massachusetts	Introduces a tax credit of 10% of qualified incremental R&D expenditures
1993	Arizona	Introduces a tax credit of 20% of qualified incremental R&D expenditures
1993	Connecticut	Introduces a tax credit of 6% of qualified incremental R&D expenditures
1993	New Hampshire	Introduces a tax credit of 7.5% of qualified incremental R&D expenditures
1994	Missouri	Introduces a tax credit of 6.5% of qualified incremental R&D expenditures
1994	New Hampshire	Increases R&D tax credit from 7.5% to 15%
1994	New Jersey	Introduces a tax credit of 10% of qualified incremental R&D expenditures
1994	Rhode Island	Introduces a tax credit of 5% of qualified incremental R&D expenditures
1995	New Hampshire	Lets R&D tax credit expire
1995	Washington	Introduces a tax credit of 7.5% of qualified incremental R&D expenditures
1996	Maine	Introduces a tax credit of 5% of qualified incremental R&D expenditures
1996	North Carolina	Introduces a tax credit of 5% of qualified incremental R&D expenditures
1997	California	Increases R&D tax credit from 8% to 11%
1997	Pennsylvania	Introduces a tax credit of 10% of qualified incremental R&D expenditures
1998	Georgia	Introduces a tax credit of 10% of qualified incremental R&D expenditures
1998	Rhode Island	Increases R&D tax credit from 5% to 16.9%
1998	Vermont	Introduces a tax credit of 10% of qualified incremental R&D expenditures
1999	California	Increases R&D tax credit from 11% to 12%
1999	Montana	Introduces a tax credit of 5% of qualified incremental R&D expenditures
1999	Utah	Introduces a tax credit of 6% of qualified incremental R&D expenditures
2000	California	Increases R&D tax credit from 12% to 15%
2000	Delaware	Introduces a tax credit of 10% of qualified incremental R&D expenditures
2000	Hawaii	Introduces a tax credit of 20% of qualified incremental R&D expenditures
2000	Maryland	Introduces a tax credit of 10% of qualified incremental R&D expenditures
2000	New Mexico	Introduces a tax credit of 4% of qualified incremental R&D expenditures
2001	Arizona	Cuts R&D tax credit from 20% to 11%
2001	Idaho	Introduces a tax credit of 5% of qualified incremental R&D expenditures
2001	Ohio	Introduces a tax credit of 7% of qualified incremental R&D expenditures

List of Changes in State Tax Credits (Continued)

Year Effective	State	Description
2001	South Carolina	Introduces a tax credit of 2.5% of qualified incremental R&D expenditures
2001	Texas	Introduces a tax credit of 4% of qualified incremental R&D expenditures
2002	Kentucky	Introduces a tax credit of 5% of qualified incremental R&D expenditures
2002	South Carolina	Increases R&D tax credit from 2.5% to 5%
2002	Texas	Increases R&D tax credit from 4% to 5%
2003	Illinois	Lets R&D tax credit expire
2003	Indiana	Increases R&D tax credit from 5% to 10%
2003	Louisiana	Introduces a tax credit of 8% of qualified incremental R&D expenditures
2003	West Virginia	Extends R&D tax credit of 10% from only 5 high-tech sectors to all sectors
2003	Arkansas	Introduces a tax credit of 20% of qualified incremental R&D expenditures
2004	Illinois	Re-introduces a tax credit of 6.5% of qualified incremental R&D expenditures
2005	Indiana	Increases R&D tax credit middle & low brackets to 15% and 12.5%
2005	Missouri	Lets R&D tax credit expire
2006	Indiana	Cuts R&D tax credit middle & low brackets to 10%
2006	Nebraska	Introduces a tax credit of 3% of qualified incremental R&D expenditures
2006	North Carolina	Lets R&D tax credit expire
2006	Oregon	Increases R&D tax credit cap from \$0.5M to \$2M
2007	New Hampshire	Re-introduces a tax credit of 10% of qualified incremental R&D expenditures
2007	North Carolina	Re-introduces a tax credit of 3.25% of qualified incremental R&D expenditures
2007	North Dakota	Increases R&D tax credit from 4% to 20%
2007	Vermont	Lets R&D tax credit expire
2007	Washington	Increases R&D tax credit from 7.5% to 15%
2008	Indiana	Increases R&D tax credit from 10% to 15%
2008	Michigan	Introduces a tax credit of 2% of qualified incremental R&D expenditures
2008	Texas	Lets R&D tax credit expire
2008	Utah	Cuts existing R&D tax credit to 5%, but introduces an additional new R&D tax credit on all qualified R&D expenditures (ambiguous)
2009	Utah	Increases R&D tax credit from 5% to 6%
2010	Arizona	Increases R&D tax credit from 11% to 13%
2010	Minnesota	Increases R&D tax credit from 6.25% to 10%
2010	Utah	Increases R&D tax credit from 6% to 9%
2011	Arizona	Increases R&D tax credit from 13% to 15%
2011	Hawaii	Lets R&D tax credit expire
2011	Michigan	Lets R&D tax credit expire
2011	Montana	Lets R&D tax credit expire
2011	New York	Introduces a tax credit of 3% of qualified incremental R&D expenditures, but eligibility is conditional on job creation covenants
2011	North Dakota	Cuts R&D tax credit from 20% to 8%
2011	Utah	Lets R&D tax credit expire
2011	Vermont	Re-introduces a tax credit of 6% of qualified incremental R&D expenditures
2011	Wisconsin	Introduces additional super credit of 100% of the qualified R&D expenditures that exceed 1.25 times the average of R&D expenditures in the 3 prior years

Table 1: Summary Statistics

The starting sample consists of all US nonfinancial firms (excluding Utilities) in Compustat from 1986 to 2011, which yields a panel of 124,504 observations for 11,091 unique firms. The sample of innovative firms consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the same period, which yields a panel of 72,587 observations for 6,058 unique firms. The table reports summary statistics of the dependent variables and main explanatory variables. The main dependent variable is the ratio of cash holdings to book assets. Cash holdings are the sum of cash and short-term marketable securities. We also present results for variables related to liquidity structure (the ratios of bank and unused bank liquidity to total liquidity), which are constructed using data from Capital IQ (available for the 2002-2011 period, 23,086 (14,504) observations for 2,866 (1,798) unique (innovative) firms). Detailed definitions for all variables are provided in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

	Compustat Sample			Innovative Firms Sample		
	Mean	Median	Std Dev	Mean	Median	Std Dev
<i>Corporate Liquidity Variables:</i>						
Cash/Book Assets	0.18	0.08	0.22	0.24	0.14	0.25
Cash/Net Book Assets	0.29	0.08	0.50	0.39	0.14	0.54
Cash/Market Value of Assets	0.14	0.07	0.20	0.16	0.09	0.21
Dollar Cash (\$M, 1990 real)	52.0	5.4	169.7	59.3	6.2	186.6
Bank Liquidity/Total Liquidity	0.29	0.02	0.37	0.23	0	0.34
Unused Bank Liquidity/Total Liquidity	0.08	0	0.22	0.07	0	0.21
<i>Innovation & State R&D Tax Credits:</i>						
R&D Expenditures/Book Assets	0.01	0	0.14	0.03	0.00	0.20
R&D Capital/Book Assets	0.15	0.01	0.28	0.30	0.19	0.33
States Adopting R&D Tax Credit (% obs)				3.3%		
States Increasing R&D Tax Credit (% obs)				5.1%		
States Cutting R&D Tax Credit (% obs)				0.8%		
<i>Baseline Firm Controls:</i>						
Cash Flow Volatility	0.37	0.37	0.11	0.39	0.41	0.10
Market-to-Book	1.96	1.47	1.44	2.20	1.63	1.63
Size (log(Book Assets), 1990 real)	4.78	4.64	2.15	4.49	4.27	2.28
Cash Flow/Book Assets	0.04	0.06	0.14	0.02	0.06	0.16
Capex/Book Assets	0.06	0.04	0.07	0.05	0.04	0.06
Dividend dummy	0.25	0	0.43	0.23	0	0.42
Acquisitions/Book Assets	0.02	0	0.06	0.02	0	0.06
<i>Channels & Additional Controls (selected):</i>						
Net Leverage	0.09	0.11	0.43	-0.01	0.01	0.46
Bank Debt/Total Debt	0.39	0.22	0.40	0.35	0.12	0.41
Secured Debt/Total Debt	0.45	0.33	0.43	0.42	0.22	0.44
Debt Rated Dummy	0.19	0	0.39	0.16	0	0.36
Net Debt Issuance/Book Assets	0.02	0	0.17	0.01	0	0.16
Net Equity Issuance/Book Assets	0.05	0	0.16	0.06	0	0.18
Cash/Book Equity	0.35	0.21	0.39	0.41	0.28	0.42
Firm Age (years)	15	10	15	14	9	14
Foreign Tax Burden/Book Assets	0.001	0	0.001	0.001	0	0.001
Foreign Income Dummy	0.30	0	0.45	0.38	0	0.48
Industry Competition (HHI)	0.07	0.05	0.06	0.05	0.04	0.05
High Tech Industry Dummy	0.25	0	0.43	0.38	0	0.48
Board Size	7.45	7	2.83	7.31	7	2.79
Classified Board Dummy	0.57	1	0.49	0.57	1	0.50
Board Independence (% Outside Directors)	0.65	0.66	0.20	0.66	0.71	0.20

Table 2: Descriptive Evidence on Corporate Cash Holdings and Liquidity Structure of Innovative Firms

The Compustat sample consists of all US nonfinancial firms (excluding Utilities) in Compustat from 1986 to 2011 (Panel A), while the sample of innovative firms consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the same period (Panel B). For each of these two samples, the table reports parameter estimates, scaled by the standard deviation of the underlying variable, from panel OLS regressions of cash holdings (Columns 1-4) and liquidity structure (Columns 5-10) on two firm-level measures of innovation, R&D expenditures and R&D capital, while controlling for standard determinants of cash (cash flow volatility, market-to-book ratio, firm size, cash flow, whose coefficients are reported; capex, acquisition expenditures, and a dummy for whether the firm pays dividend in any given year, are also included, but coefficient estimates are omitted for brevity). The interpretation of each reported coefficient is the change in the dependent variable associated with a one-standard deviation change in the determinant. For example, a one-standard deviation increase in R&D expenditures is associated with a 5.4% increase in cash holdings (Column 1). R&D capital is the stock of past R&D expenditures constructed using the perpetual inventory method. Year and 48-Fama-French industry dummies are included in all regressions. p-values (in parentheses) are clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are provided in Appendix A.

	Panel A: Compustat Sample									
	Corporate Cash Holdings				Corporate Liquidity Structure					
	Cash/ Book Assets (1)	Net Book Assets (3)	Cash/ Book Assets (4)	Probit of Bank Liquidity (5)	Bank Liquidity Total Liquidity (6)	Bank Liquidity to Total Liquidity (7)	Unused Bank Liquidity to Total Liquidity (8)	Unused Bank Liquidity to Total Liquidity (9)	Unused Bank Liquidity to Total Liquidity (10)	
R&D Expenditures	0.054*** (0.003)	0.035*** (0.004)	0.074*** (0.004)	-0.195*** (0.070)	-0.186*** (0.033)	-0.021*** (0.004)	-0.044*** (0.004)	-0.006*** (0.002)	-0.013*** (0.002)	
R&D Capital										
Cash Flow Volatility	0.017*** (0.001)	0.016*** (0.001)	0.027*** (0.002)	-0.064*** (0.011)	-0.054*** (0.011)	-0.007** (0.003)	-0.007** (0.003)	-0.002 (0.002)	-0.002 (0.002)	
Market-to-Book	0.024*** (0.001)	0.027*** (0.002)	0.046*** (0.003)	-0.009*** (0.003)	-0.011*** (0.003)	-0.032*** (0.004)	-0.038*** (0.004)	-0.006*** (0.001)	-0.008*** (0.002)	
Firm Size	-0.021*** (0.002)	-0.017*** (0.002)	-0.022*** (0.003)	0.029*** (0.003)	0.024*** (0.004)	0.000 (0.002)	-0.003 (0.002)	0.002* (0.001)	0.001 (0.001)	
Cash Flow / Book Assets	-0.002 (0.001)	-0.004*** (0.001)	0.006** (0.002)	0.018 (0.016)	0.001 (0.019)	0.004 (0.004)	0.002 (0.004)	0.005*** (0.002)	0.005*** (0.002)	
Year & Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Adjusted R ²	0.251	0.274	0.184	0.155	0.184	0.127	0.141	0.043	0.046	

Panel B: Innovative Firms Sample									
R&D Expenditures	0.052*** (0.003)	0.033*** (0.004)	0.063*** (0.004)	-0.154** (0.063)	-0.140*** (0.029)	-0.023*** (0.004)	-0.038*** (0.004)	-0.005*** (0.002)	-0.010*** (0.002)
R&D Capital									
Year & Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.251	0.273	0.151	0.177	0.177	0.109	0.127	0.045	0.042

Table 3: Validation of Changes in State R&D Tax Credits

The table reports results of linear-probability regressions of the likelihood that a state changes its R&D tax credit (Panel A), and parameter estimates from DID regressions of changes in innovation on changes in state R&D tax credits (Panel B). In Panel A, the dependent variable is a dummy that takes value of one in any given year when a state changes its R&D tax credit, with different types of changes in turn: introduction or subsequent increases (Column 1), introduction (Column 2), increases subsequent to introduction (Column 3), and cuts subsequent to introduction (Column 4). Determinants includes other state-level changes that can be potentially relevant for cash. Year and state dummies are included in all regressions. p-values (in parentheses) are clustered at the state level. Estimates in Panel B are for the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period, and for changes in R&D expenditures (Column 1), R&D capital (Column 2), Capex (Column 3), and Property, plants, and equipment (Column 4). The interpretation of each reported coefficient is the change in the dependent variable associated with an R&D tax credit change. For example, in Column 2, R&D tax credit increases are associated with an 8.8% increase in R&D capital relative to book assets. All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

Panel A: Determinants of Changes in State R&D Tax Credits				
	Introduction & Subsequent Increases (1)	Introduction (2)	Subsequent Increases (3)	Subsequent Cuts (4)
State Business Cycle Conditions				
Lagged GDP Growth	0.002 (0.003)	0.001 (0.002)	0.001 (0.003)	0.000 (0.001)
Lagged Unemployment Rate	0.021** (0.008)	0.017** (0.006)	0.004 (0.003)	0.004 (0.002)
Political Conditions				
Vote Share of Republican Presidential Candidate	0.002 (0.001)	0.001 (0.001)	0.001 (0.001)	0.000 (0.000)
Union Power				
Lagged Union Membership	-0.010 (0.007)	-0.004 (0.004)	-0.006 (0.006)	0.003 (0.003)
Changes in Other State Taxes				
Lagged Change in Corporate Taxes	0.010 (0.026)	0.013 (0.024)	-0.003 (0.012)	-0.027 (0.017)
Lagged Change in Personal Income Taxes	0.013 (0.023)	0.026 (0.021)	-0.013 (0.011)	0.004 (0.004)
Diagnosics, Wald test: All coeffs=0	2.00* (p=0.083)	2.29** (p=0.050)	0.72 (p=0.632)	1.14 (p=0.355)
State and Year fixed effects [R ²]	Yes [0.067]	Yes [0.074]	Yes [0.054]	Yes [0.057]
Panel B: Validation of Changes in State R&D Taxes				
	R&D Expenditures (1)	R&D Capital (2)	Capex (3)	PPE (4)
=1 if R&D Tax Credit Increase at t=0 (in %)	0.003** (0.002)	0.088*** (0.021)	0.001 (0.001)	0.000 (0.002)
=1 if R&D Tax Credit Cut at t=0 (in %)	-0.002** (0.001)	-0.074** (0.036)	0.001 (0.003)	0.001 (0.003)
Baseline Firm Controls, Industry-Year fixed effects	Yes	Yes	Yes	Yes

Table 4: The Impact of Innovation on Corporate Cash Holdings: Baseline Analysis of Changes in State R&D Tax Credits

The table reports parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for several different specifications and definitions of cash ratios. All regressions are estimated in the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 firm-year observations for 6,058 unique firms). The interpretation of each reported coefficient is the change in the dependent variable associated with an R&D tax credit change. For example, in the first column, an increase in state R&D tax credits is associated with a 2.1% increase in cash relative to book assets. Columns 1 to 3 report results for cash to book asset ratios, in the baseline specification (1), as well as in a more inclusive specification with leads and lags of R&D tax credit changes, and in a specification where the percentage change in the R&D tax credit is used instead of an indicator variable, respectively. Columns 4 to 7 are for alternative definitions of cash ratios, which include cash to net book assets (Column 4), cash to market value of assets (Column 5), cash minus net income to book assets (Column 6), and cash to lagged cash plus net income (Column 7). All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

	Baseline		Timing	Size of R&D Tax Credit	Alternative Definitions of Cash Ratios			
	Book Assets (1)	Cash/Book Assets (2)			Book Assets (4)	Cash/Market Assets (5)	Net Cash/Book Assets (6)	Cash/(Lag Cash + Net Income) (7)
=1 if R&D Tax Credit Increase at t=0	0.021*** (0.003)	0.013*** (0.005)	0.013*** (0.005)		0.032*** (0.006)	0.021*** (0.005)	0.026*** (0.006)	0.061*** (0.017)
=1 if R&D Tax Credit Increase at t=-1		0.009* (0.005)						
=1 if R&D Tax Credit Increase at t=+1		0.002 (0.004)						
R&D Tax Credit Increase at t=0				0.316*** (0.093)				
=1 if R&D Tax Credit Cut at t=0	-0.017*** (0.006)	-0.015** (0.007)	-0.015** (0.007)		-0.029*** (0.007)	-0.016*** (0.006)	-0.016** (0.008)	-0.057** (0.027)
=1 if R&D Tax Credit Cut at t=-1		-0.011 (0.008)						
=1 if R&D Tax Credit Cut at t=+1		-0.006 (0.009)						
R&D Tax Credit Cut at t=0				-0.219*** (0.085)				
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.168	0.245	0.245	0.152	0.139	0.186	0.170	0.191

Table 5: The Impact of Innovation on Corporate Cash Holdings: Falsification Tests

The table reports parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for two different sub-sample splits of the data based on proxies for the institutional features of the R&D tax credits that affect their effectiveness (Columns 1 to 4) and for specifications that also include changes in state investment tax credits (Columns 5 to 6). All regressions are estimated in the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 firm-year observations for 6,058 unique firms). The interpretation of each reported coefficient is the change in the dependent variable associated with a change in R&D tax credit. For example, in the first column, an increase in state R&D tax credits is associated with a 2.2% increase in cash relative to book assets. The sample is split between above vs. below median (year-prior) values of the following ex-ante proxies: state corporate tax rate (Columns 1 to 2), and growth in firm R&D expenditures with respect to their pre-treatment level (Columns 3 and 4). The changes in investment tax credits are 18 introduction events, 27 increases, and 8 cuts in state investment tax credits hand-collected by Chirinko and Wilson (2008) and therein detailed. All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with ** , * , and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

	State Corporate Tax Rate is		R&D Growth is		Response to Changes in State Investment Tax Credits	
	High (1)	Low (2)	High (3)	Low (4)	(5)	(6)
=1 if R&D Tax Credit Increase at t=0	0.022*** (0.004)	0.004 (0.012)	0.029*** (0.006)	0.005 (0.007)	0.001 (0.010)	0.020*** (0.003)
=1 if R&D Tax Credit Cut at t=0	-0.021*** (0.006)	-0.007 (0.011)	-0.030** (0.015)	-0.008 (0.007)		-0.024*** (0.007)
=1 if New Investment Tax Credit at t=0					0.001 (0.010)	-0.010 (0.010)
=1 if Investment Tax Credit Increase at t=0					-0.018** (0.009)	-0.016* (0.009)
=1 if Investment Tax Credit Cut at t=0					0.009* (0.005)	0.012** (0.006)
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.131	0.106	0.190	0.122	0.124	0.161

Table 6: The Impact of Innovation on Corporate Cash Holdings: External Validity and Robustness Tests

The table reports parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for three different sets of robustness tests (Panels A, B, and D) and parameter estimates based on alternative estimators (Panel C). Panel A considers robustness to using alternative standard errors and including additional firm-, state-, and industry-level control variables. Panel B considers robustness to controlling for potential confounds at the state level. Panel C considers robustness to using alternative estimators, which include a geographic regression discontinuity design (RDD) estimator based on firms in state border counties (Row 9), the system IV-GMM of Blundell and Bond (1998) (Row 10), an IV-DID (2-SLS) estimator that uses R&D tax credit changes as instruments for the R&D stock (estimates of the second stage regression with instrumented R&D stock are reported in Row 11), and a matched-sample DID estimator (Heckman, Ichimura, and Todd (1997)) that matches treated and control firms based on pre-treatment size, industry, and performance. Panel D examines external validity by considering different sets of treatments, which consist of including introduction events in the treatment set (Rows 13 and 15), as well as considering the introduction of only the largest (top quartile) such state R&D tax credit programs (Rows 14 and 16). All regressions are estimated in the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 firm-year observations for 6,058 unique firms). The interpretation of each reported coefficient is the change in the dependent variable associated with a change in R&D tax credit. For example, in the first row, an increase in state R&D tax credits is associated with a 2% increase in cash relative to book assets. All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, unless indicated otherwise, with ** , * , and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

	Robustness Test	Estimated Coefficient if R&D Tax Credit at t=0		Robustness Test	Estimated Coefficient if R&D Tax Credit at t=0		
		Increases (1)	Cuts (2)		Increases (1)	Cuts (2)	
Panel A: Alternative Standard Errors and Controls							
[1]	Clustering by state, control for state fixed effects	0.020*** (0.005)	-0.018** (0.008)	[9]	Geographic RDD using adjacent counties as control group	0.019*** (0.003)	-0.017** (0.008)
[2]	Control for repatriation	0.019*** (0.003)	-0.015*** (0.006)	[10]	IV-GMM	0.020*** (0.005)	-0.018*** (0.004)
[3]	Control for marginal tax rate	0.019*** (0.003)	-0.015*** (0.006)	[11]	IV-DID (2-SLS), R&D Stock is instrumented using R&D tax credits	0.068*** (0.014)	
[4]	Control for competition & high-tech	0.019*** (0.003)	-0.015*** (0.006)	[12]	Matched-sample DID: size, industry & prior performance	0.018*** (0.004)	-0.016** (0.007)
Panel B: Controlling for Potential Confounds							
[5]	Control for state business cycle	0.013*** (0.003)	-0.019*** (0.006)	[13]	OLS, All	0.012*** (0.002)	-0.017*** (0.006)
[6]	Control for state political conditions & union power	0.021*** (0.006)	-0.034** (0.015)	[14]	OLS, Top quartile new tax credits	0.021*** (0.003)	-0.017*** (0.006)
[7]	Control for state corporate income taxes	0.021*** (0.003)	-0.016*** (0.006)	[15]	Matched-sample DID: size, industry & state BC	0.018*** (0.003)	-0.028*** (0.007)
[8]	Control for state personal income taxes	0.021*** (0.003)	-0.017*** (0.006)	[16]	Matched-sample DID: size, industry & state BC, Top quartile new tax credits	0.029*** (0.004)	-0.028*** (0.007)
Panel C: Finer Control Groups & Alternative Estimators							
Panel D: External Validity							
New Credit or Increases							
Cuts							

Table 7: The Impact of Innovation on Corporate Cash Holdings: Assessing the Role of Financial Frictions & Precautionary Motives

The table reports parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for several different sub-sample splits of the data based on ex-ante proxies for the severity of financial frictions faced by firms (Panel A), as well as for the intensity of the precautionary motive to hold cash (Panel B). All regressions are estimated in the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 firm-year observations for 6,058 unique firms). The interpretation of each reported coefficient is the change in the dependent variable associated with a change in R&D tax credit. For example, in the first column, an increase in state R&D tax credits is associated with a 1.8% increase in cash relative to book assets. The sample is split between above vs. below median (pre-treatment) values of the following variables: firm size (Column 1), Kaplan and Zingales (1997) KZ-Index (Column 3), Whited and Wu (2006) WW-Index (Column 4), firm cash flows (Column 5), firm age (Column 6), firm market-to-book ratio (Column 7), firm cash flow volatility (Column 8), and by dividend payer status (Column 2). All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with **, *, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

	Panel A: Financial Frictions Proxies				Panel B: Precautionary Motive Proxies			
	Firm Size (1)	Dividend Payer (2)	KZ Index (3)	WW Index (4)	Cash Flows (5)	Firm Age (6)	M/B Ratio (7)	Cash Flow Volatility (8)
=1 if R&D Tax Credit Increase at t=0	0.018** (0.009)	0.018*** (0.421)	0.022*** (0.006)	0.021** (0.010)	0.021** (0.011)	0.030** (0.014)	0.022** (0.009)	0.019*** (0.004)
=1 if R&D Tax Credit Cut at t=0	-0.015*** (0.005)	-0.013** (0.007)	-0.021*** (0.007)	-0.019*** (0.005)	-0.019*** (0.006)	-0.026*** (0.006)	-0.019*** (0.006)	-0.015*** (0.006)
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		<u>Unconstrained</u>			<u>High</u>	<u>Old</u>	<u>Low</u>	<u>Safe</u>
=1 if R&D Tax Credit Increase at t=0	0.003 (0.004)	0.005 (0.005)	0.008* (0.004)	0.005 (0.004)	0.008* (0.005)	0.008** (0.004)	0.010 (0.006)	0.005 (0.008)
=1 if R&D Tax Credit Cut at t=0	-0.006 (0.006)	-0.008 (0.006)	-0.003 (0.007)	-0.001 (0.004)	-0.007 (0.006)	-0.007 (0.005)	-0.008 (0.007)	-0.004 (0.010)
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: The Impact of Innovation on Corporate Cash Holdings: Assessing the Role of Debt Financing Frictions

The table reports parameter estimates of the impact of changes in state R&D tax credits on corporate liquidity structure and debt financing (Panel A), and parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for several different subsample splits of the data based on ex-ante proxies for the severity of the debt financing frictions faced by firms (Panel B). All regressions are estimated in the innovative firms sample, which consists of the subsample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 (14,504) firm-year observations for 6,058 (1,798) unique firms (with information in Capital IQ)). The interpretation of each reported coefficient is the change in the dependent variable associated with a change in R&D tax credit. For example, in the second column of Panel A, an increase in state R&D tax credits is associated with a 1.5% decrease in unused bank liquidity relative to total liquidity. Specifically, in Panel A we report estimates from probit regressions of the likelihood of having bank liquidity (Column 1), DID estimates of changes in unused bank liquidity to total liquidity (Column 2), in net debt issuance (Column 3), and in net book leverage (Column 4), and estimates from probit regressions of the likelihood of having a debt structure that is specialized in bank debt (Column 5) and in secured debt (Column 6). In Panel B, the sample is split between above vs. below median (pre-treatment) values of Berger et al. (1996) asset liquidation value (Columns 1 and 2), and Balasubramanian and Sivadasan (2009) index of industry asset redeployability (Columns 3 and 4), as well as based on whether the firm has a long-term debt rating (Columns 5 and 6). All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

Panel A: The Impact of Innovation on Liquidity Structure, Net Leverage, and Debt Financing						
	Probit Bank Liquidity (1)	Unused Bank Liquidity to Total Liquidity (2)	Net Debt Issuance (3)	Net Book Leverage (4)	Probit Bank90 (5)	Probit Secured90 (6)
=1 if R&D Tax Credit Increase at t=0	-0.006*** (0.002)	-0.015*** (0.006)	-0.016*** (0.006)	-0.024*** (0.006)	-0.021** (0.007)	-0.028*** (0.011)
=1 if R&D Tax Credit Cut at t=0	0.011** (0.007)	0.014** (0.007)	0.014 (0.011)	0.022** (0.011)	0.019 (0.019)	0.018 (0.013)
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: The Impact of Innovation on Corporate Cash Holdings by Proxies of Debt Frictions						
	Resale Value		Asset Redeployability		Debt Rating	
	Low (1)	High (2)	Low (3)	High (4)	No (5)	Yes (6)
=1 if R&D Tax Credit Increase at t=0	-0.018** (0.009)	0.004 (0.003)	0.019*** (0.004)	0.012* (0.007)	0.025*** (0.009)	0.009 (0.006)
=1 if R&D Tax Credit Cut at t=0	0.016*** (0.004)	-0.002 (0.004)	-0.017*** (0.005)	-0.005 (0.010)	-0.021*** (0.004)	-0.003 (0.006)
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 9: The Impact of Innovation on Corporate Cash Holdings: Assessing the Role of Equity Financing Frictions

The table reports parameter estimates of the impact of changes in state R&D tax credits on equity financing (Panel A), and parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for several different sub-sample splits of the data based on ex-ante proxies for the severity of the equity financing frictions faced by firms (Panel B). All regressions are estimated in the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 firm-year observations for 6,058 unique firms). The interpretation of each reported coefficient is the change in the dependent variable associated with a change in R&D tax credit. For example, in the third column of Panel A, an increase in state R&D tax credits is associated with a 3.6% increase in cash relative to book equity. Specifically, in Panel A we report DID estimates of changes in net equity issuance (Column 1) and cash to book equity ratio (Column 3), and estimates from probit regressions of the likelihood of a secondary equity issue (SEO) (Column 2). In Panel B, the sample is split between above vs. below median (pre-treatment) values of the total dollar volume of SEOs in a firm's (48-FF) industry in any given year (Columns 1 and 2), the average (0, +1) cumulative abnormal return (CAR) of SEOs announcements in a firm's (48-FF) industry in any given year (Columns 3 and 4), and the standard deviation (dispersion) of analysts' EPS forecasts from IBES (Columns 5 and 6). All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

		Panel A: The Impact of Innovation on Equity Financing					
		Net Equity Issuance (1)		Probit Equity Issuance (2)		Cash/Book Equity (3)	
		Low (1)	High (2)	Low (3)	High (4)	Low (5)	High (6)
=1 if R&D Tax Credit Increase at t=0		0.023*** (0.007)	0.010 (0.016)	0.041*** (0.007)	0.020*** (0.005)	0.009 (0.006)	0.019** (0.008)
=1 if R&D Tax Credit Cut at t=0		-0.015 (0.011)	-0.009 (0.015)	-0.027* (0.014)	-0.029*** (0.009)	-0.002 (0.007)	-0.023** (0.011)
Baseline Firm Controls		Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects		Yes	Yes	Yes	Yes	Yes	Yes
		Panel B: The Impact of Innovation on Corporate Cash Holdings by Proxies of Equity Frictions					
		SEO Volume		SEO Costs		Analyst Forecast Dispersion	
		Low (1)	High (2)	Low (3)	High (4)	Low (5)	High (6)
=1 if R&D Tax Credit Increase at t=0		0.024*** (0.004)	0.010 (0.016)	0.001 (0.023)	0.020*** (0.005)	0.009 (0.006)	0.019** (0.008)
=1 if R&D Tax Credit Cut at t=0		-0.021*** (0.003)	-0.009 (0.015)	-0.009 (0.020)	-0.029*** (0.009)	-0.002 (0.007)	-0.023** (0.011)
Baseline Firm Controls		Yes	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects		Yes	Yes	Yes	Yes	Yes	Yes

Table 10: The Impact of Innovation on Corporate Cash Holdings: Assessing the Role of Agency, Repatriation, and Industry Competition

The table reports parameter estimates from DID regressions of changes in cash holdings to book assets on changes in state R&D tax credits for several different sub-sample splits of the data based on ex-ante proxies for repatriation incentives and product market competition (Panel A), as well as of the severity of agency frictions faced by the firm (Panel B). All regressions are estimated in the innovative firms sample, which consists of the sub-sample of all US nonfinancial firms (excluding Utilities) in Compustat that report non-zero R&D expenditures in at least one year over the 1986 to 2011 period (72,587 firm-year observations for 6,058 unique firms). The interpretation of each reported coefficient is the change in the dependent variable associated with a change in R&D tax credit. For example, in the second column, an increase in state R&D tax credits is associated with a 1.5% increase in cash relative to book assets. In Panel A, the sample is split between above vs. below median (pre-treatment) values of the foreign tax burden measure of Foley, Hartzell, and Titman (2007) (Columns 1 and 2), the (48-FF) industry Herfindahl-Hirschman Index (HHI) of sales (Columns 5 and 6), and based on whether the firm reports foreign income in a given year (Columns 3 and 4). In Panel B, we consider only the sub-sample of firms in relatively concentrated industries (those with above-median HHI) and further split the sample between above vs. below median (pre-treatment) values of board size (Columns 1 and 2), board independence (Columns 5 and 6), and based on whether the firm has a classified board of directors (Columns 3 and 4). All specifications are estimated in first differences to remove firm fixed effects in the levels equations, and lagged changes in the firm-level controls of the baseline specification (1) as well as year-industry(48-FF) dummies are included. p-values (in parentheses) are clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively. Variable definitions are in Appendix A. The detailed list of changes in state R&D tax credits is in Appendix B.

Panel A: The Impact of Innovation on Corporate Cash Holdings by Proxies of Repatriation & Product Market Competition									
	Foreign Tax Burden		Foreign Income >0		Industry HHI				
	High (1)	Low (2)	Yes (3)	No (4)	Low (5)	High (6)			
= 1 if R&D Tax Credit Increase at t=0	-0.007 (0.007)	0.015*** (0.005)	0.007* (0.004)	0.024*** (0.005)	0.017*** (0.003)	0.013 (0.009)			
= 1 if R&D Tax Credit Cut at t=0	-0.005 (0.011)	-0.014* (0.008)	-0.009 (0.006)	-0.023* (0.012)	-0.017*** (0.006)	-0.006 (0.008)			
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes			
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes			
Panel B: The Impact of Innovation on Corporate Cash Holdings by Proxies of Agency & Governance Frictions									
	Board Size in			Board Independence (% Outside Directors) in High HHI Industries					
	High (1)	High (2)	No (3)	High (4)	High (5)	Low (6)			
= 1 if R&D Tax Credit Increase at t=0	0.005 (0.005)	0.013*** (0.005)	0.007 (0.007)	0.018** (0.007)	0.010** (0.004)	0.015*** (0.005)			
= 1 if R&D Tax Credit Cut at t=0	-0.007 (0.007)	-0.017* (0.010)	-0.008 (0.008)	-0.017* (0.010)	-0.007 (0.007)	-0.020* (0.012)			
Baseline Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes			
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes			

Figure 1: History of Changes in State R&D Tax Credits

This figure shows the pattern of changes in all state R&D tax credits (subsequent to their introduction) between tax years 1987 and 2011. The left column shows the pattern of cuts in state R&D tax credits, and the right column shows the pattern of increases in state R&D tax credits. We hand-collected this information for all U.S. states using a variety of sources. The State Tax Handbook (various years) and Wilson (2009) provided the starting point to get a summary list of R&D tax credits available in any given state at a particular point in time. We then cross-checked this information by verifying the passage of state tax bills and obtaining information on the year when a given tax credit becomes effective by performing keyword searches in Lexis-Nexis (State Net) and online searches of state code legislation and tax forms on the states' Department of Revenue websites.

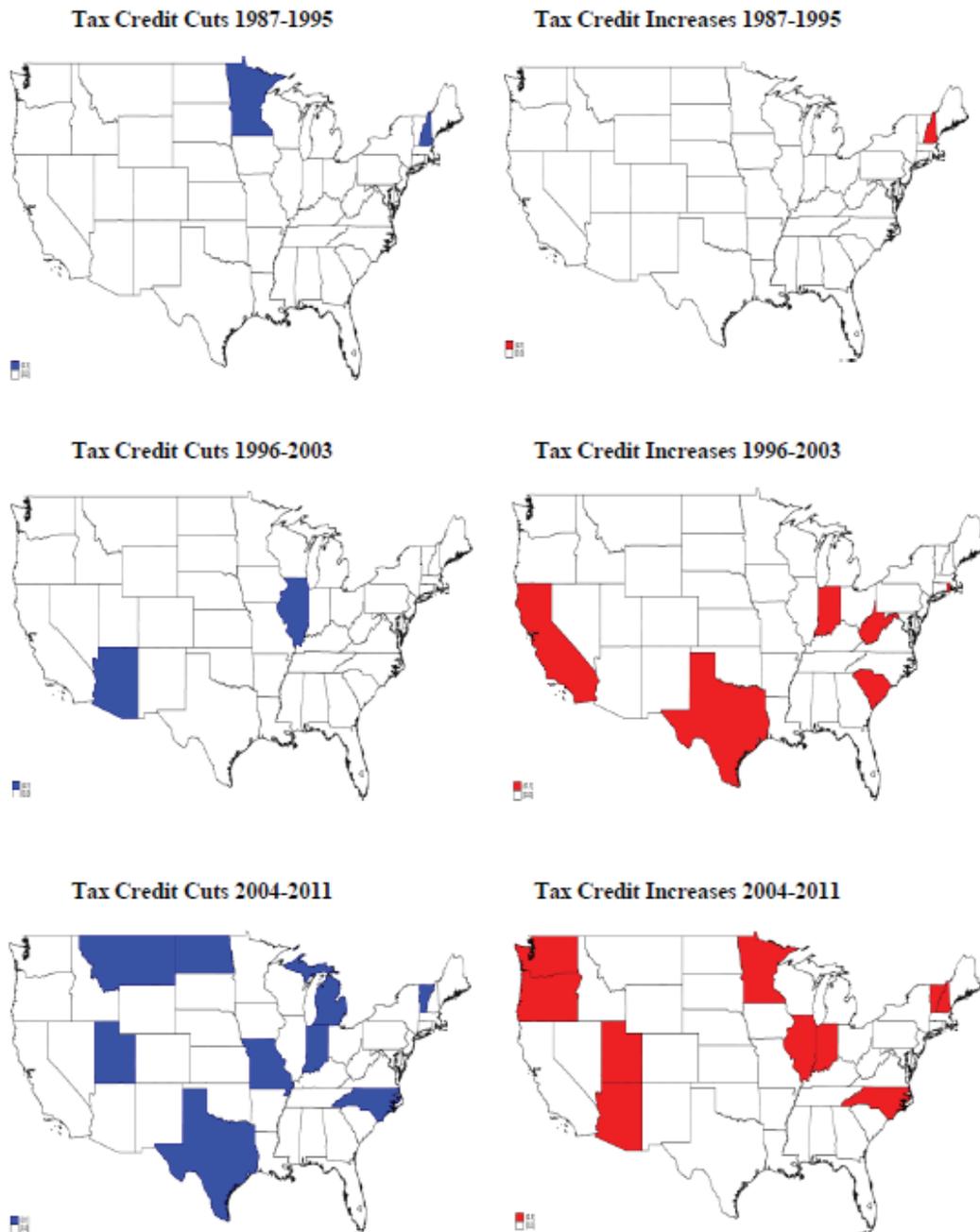


Figure 2: Annual Changes in Cash Holdings Around Changes in State R&D Tax Credits

This figure plots average annual within-firm changes in cash to book asset ratios for each year in a five-year window around the year when a state increases (Panel A) or cuts (Panel B) its R&D tax credit ($t=0$). Plotted changes are in excess of contemporaneous cash changes in the firm's 48-FF industry, to remove the influence of time-varying changes in industry conditions, and of predicted changes based on pre-treatment cash levels, to control for partial adjustment of cash. The solid, red bars are for treated firms and the dotted, blue bars are for controls, and the difference between the two bars in a given year – i.e., the difference-in-difference estimate – is displayed for $t=0$ (with its respective (two-sided) t -test of significance using standard errors clustered at the firm level, with ***, **, and * denoting significance at the 1%, 5%, and 10% level, respectively).

