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Review of Quantitative Finance and Accounting
https://doi.org/10.1007/s11156-026-01558-x

ORIGINAL RESEARCH

The effects of R&D tax credit and market competition policies on firms' zero-leverage behaviour

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Received: 26 September 2024 / Accepted: 4 October 2026
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Abstract
Motivated by the characteristics of R&D and its co-movement with the rising prevalence of zero-leverage firms over the past four decades, we investigate the effects of US R&D tax incentive and import tariff policies on zero-leverage behaviour. We find that the number of R&D-intensive firms has increased since the introduction of the R&D tax credit in 1981, and that zero-leverage firms are disproportionately concentrated among R&D firms. Both the increase in R&D investment and the rising sensitivity of leverage decisions to R&D contribute to this pattern. In addition, intensified market competition driven by tariff reductions significantly increases the likelihood of zero leverage among R&D firms, but not among non-R&D firms. Overall, our findings suggest that R&D tax incentives and trade liberalisation policies have played important roles in shaping the long-term trend of zero-leverage behaviour in the United States.

Keywords Zero-leverage · US R&D tax incentive policies · Import tariff policies · R&D · Market competition · Capital structure

JEL classification G32 · L10 · O32

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Published online: 27 October 2026

1 Introduction

Capital structure theories suggest that firms should maintain an optimal level of debt. This allows them to benefit from tax advantages and signal financial strength and growth potential to the markets.[1] Nevertheless, recent studies find a growing trend of firms adopting a capital structure with zero outstanding debt on a global scale (Bessler et al. 2013; Strebulaev and Yang 2013; D'Mello and Gruskin, 2014; DeAngelo et al. 2018; El Ghoul et al. 2018; Lotfaliei 2018). The growing prevalence of zero-leverage firms has become an increasingly important topic in corporate finance and risk management and has important implications for policymaking. Unlike their traditionally leveraged counterparts, these firms adopt a distinct financial strategy that prioritises financial flexibility over the conventional benefits of debt financing, such as tax shields and agency cost mitigation. Such behaviour challenges conventional capital structure theories by reducing bankruptcy risk and enhancing firms' resilience to economic downturns and industry shocks. This pattern is particularly evident among R&D-intensive firms operating in highly competitive industries, where financial flexibility is often a critical determinant of long-term survival and innovation. Understanding the drivers behind zero-leverage policies, particularly in relation to R&D investment and market competition, is thus essential for gaining insights into corporate decision-making and for informing policy design that balances financial stability with the need to promote innovation and economic growth.

The theoretical link between R&D investment and zero-leverage choice originates from Arrow (1962) and Hall (2002), who demonstrate that R&D investment requires substantial capital but faces challenges in accessing debt financing. This difficulty arises from the unique features of R&D investments, which generate intangible assets that lack collateral, entail a high risk of failure, and are subject to information asymmetries (e.g., Hall and Lerner 2010; Brown and Petersen 2011). Empirical evidence from Brown et al. (2009) reports that young US public firms in high-technology industries predominantly rely on internal cash flow and external equity to finance their R&D activities.

Theoretical models developed by Brander and Lewis (1986), Maksimovic (1988), and Bolton and Scharfstein (1990) suggest that, in highly competitive industries, firms tend to adopt lower leverage in order to retain financial flexibility and mitigate risk exposure. Consistent with this view, Valta (2012) and Xu (2012) show that firms operating in such industries face higher borrowing and bankruptcy costs. Similarly, Dang (2013) provides evidence that UK firms with strong growth prospects are more likely to maintain zero leverage as a means of preserving financial flexibility.

Both theoretical and empirical studies also demonstrate that market competition interacts closely with R&D investment in shaping firms' financing policies (Lyandres and Palazzo 2016; Thakor and Lo 2022). Firms operating in highly competitive industries tend to invest more in R&D to sustain their competitive advantage (Aghion et al. 2005); however, such investment can significantly reduce profitability and cash flows, thereby increasing the cost of debt and the risk of bankruptcy (Hovakimian et al. 2001; Hoberg and Phillips 2010a; Xu 2012; Curtis et al. 2020; Chen et al. 2021). As a result, firms may prefer to avoid debt financing and adopt a zero-leverage policy. Recent studies show that US firms rely on cash

[1] See for example, the trade-off theory of Kraus and Litzenberger, 1973; DeAngelo and Masulis, 1980; Bradley et al. 1984; the signalling and market timing of Harris and Raviv 1990 and Baker and Wurgler 2002; and the agency theory of Jensen and Meckling 1976 and Jensen 1986.

reserves to align R&D investment strategies with industry competition dynamics (He and Wintoki 2016; Lyandres and Palazzo 2016; Begenau and Palazzo 2021; Thakor and Lo 2022), suggesting that the interaction between market competition and R&D investment may be an important factor influencing firms' zero-leverage policies.

In this study, we explore the impacts of R&D investment, market competition, and their interaction on the zero-leverage behaviour. Following the introduction of the US Federal R&D tax credit in 1981, 32 states had implemented similar tax credits for company-funded R&D by 2006 (Wilson 2009). Our first hypothesis posits that these tax credit policies significantly increase the number of R&D-intensive firms. These firms often encounter constraints in accessing debt financing due to the intangible nature of R&D assets and the high uncertainty associated with innovation. As a result, they are more likely to avoid debt financing, thereby contributing to the rise of the zero-leverage phenomenon in the US.

Our second hypothesis is that intensified market competition, driven by changes in import tariff policies, is also a key determinant of a firm's zero-leverage policy. In highly competitive industries, firms often face lower profit margins and greater cash flow volatility. By adopting a zero-leverage policy, they can preserve financial flexibility and mitigate the risk of financial distress. This, in turn, enables them to invest more in R&D and product development to enhance competitiveness and implement aggressive pricing strategies. We therefore expect market competition to have a significant impact on firms' zero-leverage behaviour, with the effect being more pronounced among R&D-intensive firms.

Using the US-listed firm data for the period 1980 to 2017, we employ the logit models to examine the effects of R&D and market competition on firms' zero-leverage behaviour. To further investigate the impact of R&D on the rise in zero-leverage behaviour, we decompose the effect of R&D into the changing factor and changing sensitivity components. The changing factor component captures the increase in zero-leverage firms driven by higher R&D expenditure, while the changing sensitivity component reflects the rise associated with the reinforced effect of R&D investment on zero-leverage behaviour. To explore the impacts of R&D and import tariff policies on zero-leverage behaviour, we further employ a propensity score matching approach and conduct difference-in-differences (DID) analyses, using the introduction of US R&D tax incentives and changes in industry-level import tariffs as plausibly exogenous shocks.

Our results show that firms' zero-leverage behaviour is strongly influenced by R&D activity and market competition. Specifically, zero-leverage firms are concentrated among R&D-intensive firms and those operating in highly competitive industries. The direct effect of R&D on zero-leverage behaviour is significantly positive and has intensified over the past four decades. This effect is driven by both increased R&D spending and a growing sensitivity of zero-leverage behaviour to R&D investment. Moreover, market competition exerts a significantly positive impact on zero-leverage behaviour for R&D-intensive firms, but has no statistically significant effect for non-R&D firms. We find robust evidence consistent with a causal interpretation of the effects of both R&D and market competition on firms' zero-leverage behaviour.

Our study contributes to several strands of the literature. First, we extend the literature on the effects of R&D tax credit policies. Numerous studies document that such policies positively influence R&D investment (Hall 1993; Hall and Van Reenen 2000; Bloom et al. 2002; Rao 2016). A related body of research demonstrates that R&D investment affects firms' financing decisions (e.g., Hall 2002; Brown et al. 2009; He and Wintoki 2016). How-

ever, none of these studies explores the link between R&D tax incentives and firms' zero-leverage decisions. This represents an important yet overlooked channel through which the side effects of R&D tax policies can be evaluated. We examine this underexplored aspect of R&D tax policy and show evidence that the US R&D tax incentive policies have indirectly contributed to the rise in zero-leverage firms.

Second, our study contributes to the literature on the interaction between market competition and R&D investment. A substantial body of evidence suggests that intensified market competition stimulates R&D activity and influences firms' financial policies (Aghion et al. 2005; Lyandres and Palazzo 2016; Thakor and Lo 2022). However, the effect of market competition on firms' zero-leverage decisions has not been comprehensively explored. Our findings indicate that market competition plays a significant role in explaining zero-leverage behaviour. More importantly, we show that market competition interacts with R&D, and its impact on zero-leverage decisions is only observed among R&D-intensive firms.

Third, our study also contributes to the literature on the zero-leverage puzzle. Existing research has proposed several explanations for this puzzle, including market size, profitability, and liquidity (Graham 2000), financial constraints (Devos et al. 2012; Bessler et al. 2013; DeAngelo et al. 2018), human capital (Lambrecht and Pawlina 2013), national culture (El Ghoul et al. 2018), the hedging value of future debt capacity (Lotfaliei 2018), and the cost of debt's impact on shareholder value (D'Mello et al. 2018). Using the US R&D tax incentives and import tariff policies as exogenous shocks, we examine the impact of these policies on firms' zero-leverage decisions through difference-in-differences analyses. Our findings provide new insights into the puzzle and suggest that the US R&D tax credit and market competition policies stimulate R&D investment and intensify domestic competition, which in turn contribute to the increasing prevalence of zero-leverage behaviour.

Our findings have important implications for policymakers in designing incentive schemes to promote innovation. While innovation and market competition are well known to boost productivity and long-term economic growth (Romer 1990; Aghion et al. 1999), passive zero-leverage behaviour may increase the cost of capital for R&D firms and ultimately hinder aggregate growth. Policymakers should therefore account for such unintended consequences when formulating innovation-related policies.

2 Related literature

In this section, we provide an overview of the two mutually related research areas. First, we discuss the studies that examine R&D investment, R&D tax incentives, and corporate financing decisions. Second, we review the studies that link market competition and corporate financing decisions.

2.1 R&D investment, R&D tax incentives, and corporate financing decisions

R&D is widely recognised as a key driver of long-term economic growth (Romer 1990; Grossman and Helpman 1991; Aghion and Howitt 1992). Since 1981, the introduction of R&D tax credit policies for company-funded research has led to a sharp increase in R&D investment among US firms. R&D investment exhibits two distinct characteristics that influence firms' financing decisions. First, it primarily generates knowledge-based intan-

gible assets, with a substantial share of expenditure allocated to human capital, particularly the wages of scientists and engineers (Arrow 1962; Jaggia and Thakor 1994; Hall 2002; Berk et al. 2010; Lambrecht and Pawlina 2013). Second, R&D projects are inherently high-risk and yield uncertain returns, especially in their early stages. Due to these characteristics, firms often face financial constraints when seeking to borrow to fund R&D activities (Himmelberg and Petersen 1994; Brown et al. 2009).

On the other hand, high leverage increases financial constraints and bankruptcy risk, which may force firms to reduce their R&D investment. Brown and Petersen (2011) show that financially constrained US firms rely on cash holdings to smooth R&D spending. Morellec et al. (2012) find that financial leverage negatively affects innovation by increasing bankruptcy costs. He and Wintoki (2016) and Li and Luo (2020) further report that R&D-intensive firms in high-technology industries maintain high levels of cash reserves.

Building on these insights, we hypothesise that the rising prevalence of zero-leverage firms is indirectly driven by exogenous shocks stemming from R&D tax credit policies. Specifically, these policies significantly increase firms' R&D investment, prompting R&D-intensive firms to rely on equity issuance and cash holdings rather than debt financing. As a result, they are more likely to become zero-leveraged (e.g., Hall 1993; Mamuneas and Nadiri 1996; Bloom et al. 2002; Wilson 2009). Hence, we expect zero-leverage firms to be disproportionately concentrated among R&D-intensive firms.

2.2 Market competition and corporate financing decisions

Numerous studies find that market competition affects corporate capital structure decisions. Valta (2012) argues that increased competition reduces market power and lowers firm profitability, thereby increasing cash flow risk, default risk, and bankruptcy costs, which collectively raise the cost of debt (Titman 1984; Brander and Lewis 1986; Maksimovic 1988; Raith 2003; Miao 2005; Irvine and Pontiff 2009; Hoberg and Phillips 2010a; Gu 2016). Consequently, firms operating in highly competitive industries are more likely to borrow less in order to preserve financial flexibility and mitigate risk exposure. Dang (2013) finds evidence that UK firms' zero-leverage policy is partly driven by the desire to enhance and maintain financial flexibility. Phillips (1995), MacKay and Phillips (2005), and Xu (2012) further show that firms in competitive industries rely on external equity issuance and asset sales to raise capital and repay debt. This behaviour, in turn, leads to substantially lower leverage ratios.

Market competition also influences firms' incentives to invest in R&D. Thakor and Lo (2022) and Lyandres and Palazzo (2016) develop theoretical models suggesting that greater market competition discourages investment in assets-in-place while encouraging greater investment in R&D (Aghion et al. 2005). However, R&D investments in highly competitive industries tend to be less profitable, thereby increasing financial risk and reducing firms' access to debt financing. As a result, R&D-intensive firms often accumulate excess cash to support R&D activities and may passively become zero-leveraged. Xu (2012) and Hombert and Matray (2018) provide empirical evidence that global import competition reduces firm profitability, but the effects differ between R&D and non-R&D firms. Taken together, the theoretical and empirical literature suggests that market competition is a significant and positive determinant of the likelihood that a firm is zero-leveraged, with this effect being even more pronounced among R&D-intensive firms.

3 Data and methodology

Our sample comprises listed firms traded on the NYSE, AMEX, and NASDAQ from 1980 to 2017. We select 1980 as the start of the sample period to capture the first wave of R&D growth (Brown et al. 2009). Firm-level accounting data are obtained from Compustat, excluding financial firms (Standard Industrial Classification (SIC) codes 6000–6999) and utilities (SIC codes 4900–4999). All nominal values are deflated to constant year-2000 US dollars using the US Consumer Price Index (CPI) from the Organisation for Economic Co-operation and Development (OECD). Following Strebulaev and Yang (2013), we exclude observations with a total book value of assets below US$10 million to mitigate the effects of heterogeneity among small firms and reduce noise in accounting data. Observations with missing book leverage ratio data are also removed. The final sample consists of 154,712 firm-year observations covering 15,218 unique firms.

We define firm i as a zero-leverage firm in year t if its total book leverage ratio is equal to zero. This ratio is calculated as the sum of short-term and long-term debt divided by the book value of total assets. R&D firms are defined as those reporting non-zero capitalised R&D stock in a given year, while non-R&D firms are those with zero R&D stock. R&D stock is constructed using the perpetual inventory method (Hall et al. 2005).

We replace missing R&D data with zero. This imputation may potentially introduce bias by treating firms with unreported but actual R&D activity as having no innovation, as some firms may strategically withhold R&D information (Koh and Reeb 2015). Specifically, it may bias the results towards finding no relationship between R&D and zero-leverage decisions. For example, if a firm is incorrectly classified as having zero R&D expenditure when it actually invests in R&D, the observed relationship between R&D and zero-leverage decisions would be attenuated, as the firm's true innovation activity is not accurately captured. Such misclassification biases the tests in favour of detecting no effect of R&D on zero-leverage decisions. However, Curtis et al. (2020) argue that Accounting Standards Codification 730 (formerly Statement of Financial Accounting Standards No. 2) requires the separate disclosure of material R&D expenditure, which results in a relatively low proportion of firms with missing R&D data. Therefore, given this downward bias, the replacement method makes our findings more conservative; any significant R&D effects identified are likely to be understated.

Other commonly used approaches in the literature include replacing missing values with the industry median and excluding firms with missing R&D data. However, imputing missing R&D values with the industry median ignores firm-level heterogeneity and may distort the variance-covariance structure of the data. Excluding firms with missing R&D data can introduce selection bias, as R&D non-reporting may not be random. In unreported robustness tests, we implement both alternative approaches and find that our main results remain qualitatively unchanged.

We use the Herfindahl–Hirschman Index (HHI), sourced from Compustat, to measure industry competition. The HHI is calculated as the sum of the squared market shares of firms' sales within a three-digit SIC industry (Giroud and Mueller 2010). A higher HHI indicates lower market competition, while a lower HHI reflects a more competitive industry environment.

We use a logit model to test the effect of R&D on firms' zero-leverage decisions.

$$ln\frac{P(probability\ of\ being\ zero-levered)_{it}}{1-P(probability\ of\ being\ zero-levered)_{it}}=\beta_i X_{i,\,t-1}+\epsilon_{it} \tag{1}$$

where $P_{it}=1/[1+e^{-(\beta_i X_{i,t-1}+e)}]$ is the probability that firm i is unlevered in year t. The left-hand side variable of Eq. (1) is set to one if firm i has zero leverage in year t, and zero otherwise. X is a vector of explanatory variables including:

$$\begin{gathered}\beta_i X_{i,\,t-1}=\beta_0+\beta_1 R\&D_{i,t-1}+\beta_2 Log\,(size)_{i,t-1}\\ +\beta_3 Market-to-book_{i,t-1}+\beta_4 Profitability_{i,t-1}\\ +\beta_5 Tangibility_{i,t-1}+\beta_6 Dividend\ payer_{i,t-1}+\\ \beta_7 Dividend\ payout_{i,t-1}+\beta_8 Earnings\ volatility_{i,t-1}\\ +\beta_9 Ind.Frac.ZL_{i-1}+\beta_{10} Init.ZL_i+\beta_{11}\\ Capital\ expenditure_{i,t-1}+\beta_{12} Abnormal\ Cap.Ex_{i,t}\\ +\beta_{13} Asset\ sale_{i,t-1}+\beta_{14} log\,(age)_{i,t-1}+\upsilon_j+\upsilon_t\end{gathered} \tag{2}$$

We use three measures of R&D: the ratio of R&D expenditure to total assets (*R&D-to-assets*), the ratio of R&D expenditure to sales (*R&D-to-sales*), and an R&D dummy variable that equals one if a firm reports positive R&D expenditure in year t, and zero otherwise. Following the literature on capital structure (e.g., Rajan and Zingales 1995; Titman and Wessels 1988; Strebulaev and Yang 2013), we include a comprehensive set of control variables in Eq. (2). These variables capture firm-level characteristics commonly associated with leverage decisions, including firm size, growth opportunities, profitability, tangibility, dividend policy, earnings volatility, investment activity, asset sales, initial leverage status, the industry proportion of zero-leverage firms, and firm age. To mitigate endogeneity concerns, all control variables are lagged by one period, except for Abnormal Capital Expenditure, which is measured contemporaneously, following Strebulaev and Yang (2013).

We control for firm size (*Log*(*size*), age (*Log*(*age*), profitability (*Profitability*), and tangibility (*Tangibility*) to account for firms' borrowing ability and financing preferences. Firm size, measured as the logarithm of total assets, captures both financing capacity and reliance on internal resources. Larger firms generally benefit from reduced information asymmetry and lower bankruptcy costs (Ferri and Jones 1979; Warner 1977), but may also rely more on retained earnings. Firm age, calculated as the logarithm of one plus the number of years since incorporation, is included to capture financial constraint, as older firms typically have longer credit histories (Cooley and Quadrini 2001). Profitability, defined as earnings before interest and taxes over total assets, may influence leverage in multiple ways depending on the theoretical perspective, including pecking order, trade-off, or market-timing theories (Myers and Majluf 1984; Jensen 1986; Baker and Wurgler 2002). Tangibility, the ratio of fixed assets to total assets, serves as a proxy for collateral value and is typically associated with greater borrowing capacity, although it may also relate to agency concerns in low-leverage settings (Titman and Wessels 1988).

To capture financing constraints and internal resources, we also include a dividend-paying dummy (*Dividend payer*) and the dividend payout ratio (*Dividend payout*) as suggested in Fazzari et al. (1988) and Strebulaev and Yang (2013). We further control for growth opportunities using the market-to-book ratio (*Market-to-book*), as high-growth firms tend to rely less on debt to avoid financial distress (Rajan and Zingales 1995). Earnings volatility (*Earnings volatility*), measured as the standard deviation of profitability, reflects firm-level risk and is generally expected to discourage borrowing (Graham 2000).

Initial zero-leverage status (*Init.ZL*) is included as a dummy indicating whether a firm is unlevered in the first year it appears in the database, capturing persistent firm-specific preferences. The industry fraction of zero-leverage firms (*Ind.Frac.ZL*), calculated at the Fama-French 12-industry level, controls for the evolution of unlevered behaviour in the industry composition (Strebulaev and Yang 2013).

In terms of investment activity, we include capital expenditure scaled by total assets to reflect current investment levels (*Capital expenditure*), which may influence firms' demand for financing resources (Ovtchinnikov 2010). Abnormal capital expenditure (*Abnormal Cap.Ex*) is defined as the deviation of current capital expenditure from its three-year historical average and is used to proxy for firms' anticipation of future investment opportunities (Titman et al. 2004). Asset sales, scaled by total assets, are also included, as zero-leverage firms may rely on asset disposals to meet financing needs (Strebulaev and Yang 2013).

We include industry fixed effects (v_j) based on the Fama and French (1997)'s 12-industry classification, which control for persistent sector-level differences in capital structure decisions.[2] Year fixed effects (v_t) are also included to account for macroeconomic trends and other time-varying factors affecting all firms. Variable definitions and construction details are reported in the appendix.

4 Empirical results

4.1 Initial results

Figure 1 presents the proportion of zero-leverage firms over time, as well as the proportions of R&D and non-R&D zero-leverage firms, classified based on capitalised R&D stock. In the 1980 s, both groups exhibited similar proportions of zero-leverage firms, at approximately 3%. Since the early 1990 s, however, the proportion of zero-leverage firms among R&D firms has increased markedly, rising from around 4% to 14%. In contrast, the proportion among non-R&D firms has only experienced a modest increase, from approximately 4% to 5–6%. These patterns suggest that the overall upward trend in the prevalence of zero-leverage firms may be largely driven by R&D firms.

Table 1 reports the moving averages of the cross-sectional means of the variables used in the baseline regressions.[3] All variables are winsorised at the 1 st and 99th percentiles, and observations with missing values are excluded. We compute annual cross-sectional means and then average them over time. On average, 12% of firms (319/2,613) are zero-leveraged each year, with over two-thirds of them (218/319) being R&D-active.

Following Strebulaev and Yang (2013), we construct a sample of proxy firms that operate in the same three-digit SIC industry and year, have similar total book assets, and adopt the same dividend payout policy as zero-leverage firms.[4] A comparison between columns 1 and 3 shows that, on average, zero-leverage firms are weaker than both the full sample and their matched proxy firms in these characteristics.

[2] Our results remain robust when including industry fixed effects based on three-digit SIC classifications. These additional results are available from the authors upon request.

[3] The summary statistics for other variables are reported in Appendix 2.

[4] We choose up to four proxy firms for each zero-leverage firm with the closest log(size) that are between 0.5 and 2 times the corresponding zero-leverage firm's log(size).

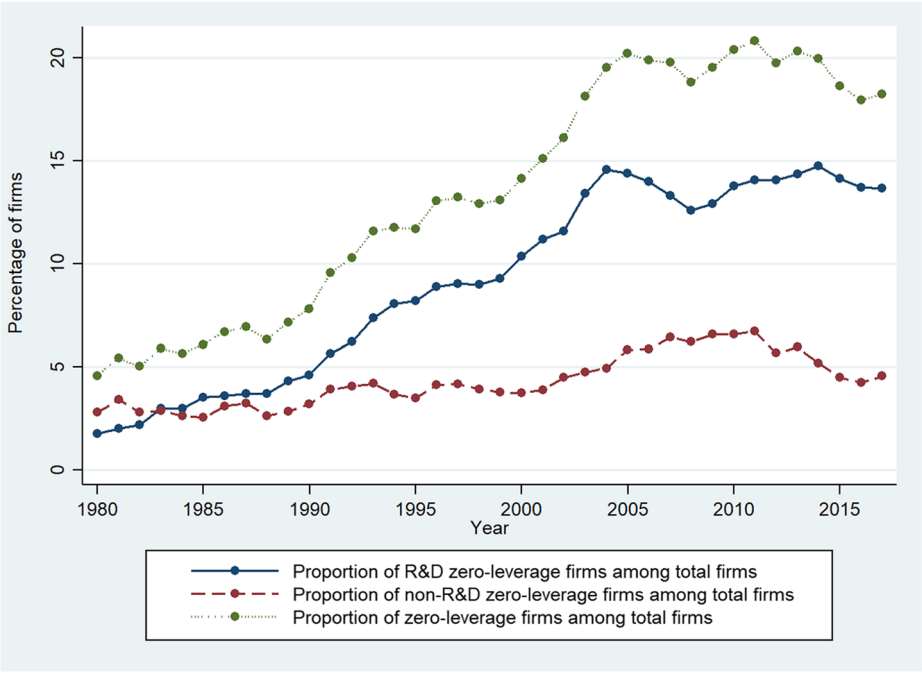


Fig. 1 The proportion of zero-leverage firms by firms' R&D engagement 1980–2017. The dotted line represents the proportion of zero-leverage firms over the total number of firms in each year, the solid line the proportion of zero-leverage firms that have positive R&D stock (R&D zero-leverage firms) over the total number of firms, and the dashed line the proportion for zero-leverage firms that do not have R&D stock (non-R&D zero-leverage firms). Source: Authors' own calculation

We further split the zero-leverage sample by R&D stock in columns 4 and 5, and report p-values from t-tests of mean differences in firm characteristics between R&D and non-R&D firms in column 6. The comparison suggests that R&D zero-leverage firms are financially weaker, possibly due to the riskiness of their R&D investment. We formally examine the role of R&D in the subsequent sections.

4.2 The impact of R&D on zero-leverage behaviour over time

Table 2 reports the estimation results and average marginal effects from the logit model specified in Eq. (1). The results indicate that the R&D-to-sales ratio, R&D-to-assets ratio, and R&D dummy are all positively and significantly associated with the likelihood of a firm being zero-leveraged.

The marginal effect of the R&D-to-sales ratio in column 4 is 0.016. This implies that, for example, increasing the R&D-to-sales ratio from 1% to 2% raises the probability of being zero-leveraged by approximately 0.5%.[5] Similarly, the marginal effect in column 5 shows that, for example, if the R&D-to-assets ratio increases from 1% to 2%, the probability of being zero-leveraged increases by 5.5%. Column 6 refers to the proxy R&D dummy and shows that the probability of being zero-leveraged for R&D firms is, on average, 1.4%

[5] (log0.02-log0.01)×0.016 = 0.0048 or 0.5%.

Table 1 Descriptive statistics of firm characteristics

Variable	Total	ZL	Proxy	*R*&D ZL	Non-*R*&D ZL	Diff.-in-Mean	ZL in high competition industries	ZL in low competition industries	Diff.-in-Mean
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Book leverage	0.253	0.000	0.203	0.000	0.000	-	0.000	0.000	-
	(0.263)	(0.000)	(0.277)	(0.000)	(0.000)		(0.000)	(0.000)	
R&D-to-sales	0.122	0.270	0.266	0.388	0.000	0.000	0.406	0.064	0.000
	(0.562)	(0.845)	(0.605)	(0.994)	(0.000)		(1.042)	(0.229)	
R&D-to-assets	0.039	0.073	0.073	0.107	0.000	0.000	0.096	0.037	0.000
	(0.077)	(0.099)	(0.103)	(0.105)	(0.000)		(0.106)	(0.069)	
R&D dummy	0.467	0.580	0.605	0.893	0.000	0.000	0.670	0.439	0.000
	(0.498)	(0.481)	(0.478)	(0.296)	(0.000)		(0.437)	(0.495)	
Compustat HHI	0.228	0.205	0.174	0.191	0.243	0.000	0.103	0.337	0.000
	(0.169)	(0.157)	(0.127)	(0.148)	(0.165)		(0.029)	(0.158)	
Log(size)	5.569	4.530	4.589	4.422	4.751	0.000	4.489	4.606	0.086
	(1.814)	(1.269)	(1.249)	(1.246)	(1.280)		(1.272)	(1.263)	
Market-to-book	1.684	2.234	1.911	2.363	1.960	0.000	2.379	2.009	0.000
	(1.123)	(1.611)	(1.348)	(1.674)	(1.413)		(1.650)	(1.471)	
Profitability	0.092	0.079	0.050	0.054	0.139	0.000	0.053	0.120	0.000
	(0.155)	(0.202)	(0.193)	(0.211)	(0.155)		(0.216)	(0.164)	
Tangibility	0.298	0.187	0.237	0.140	0.276	0.000	0.181	0.203	0.093
	(0.222)	(0.175)	(0.199)	(0.118)	(0.224)		(0.170)	(0.177)	
Dividend payer	0.411	0.387	0.280	0.329	0.510	0.000	0.322	0.481	0.001
	(0.472)	(0.440)	(0.396)	(0.413)	(0.472)		(0.404)	(0.471)	
Dividend payout	0.010	0.017	0.007	0.014	0.023	0.000	0.013	0.022	0.000
	(0.019)	(0.028)	(0.017)	(0.025)	(0.032)		(0.024)	(0.032)	
Earnings volatility	0.072	0.097	0.095	0.106	0.078	0.000	0.104	0.086	0.000
	(0.066)	(0.078)	(0.079)	(0.081)	(0.065)		(0.082)	(0.066)	
Init. ZL	0.109	0.363	0.164	0.352	0.361	0.613	0.393	0.323	0.000
	(0.306)	(0.477)	(0.361)	(0.477)	(0.472)		(0.485)	(0.463)	
Ind. Frac. ZL	0.124	0.150	0.167	0.175	0.108	0.000	0.174	0.122	0.000
	(0.065)	(0.066)	(0.060)	(0.063)	(0.040)		(0.057)	(0.053)	
Capital expenditure	0.062	0.049	0.056	0.040	0.066	0.000	0.050	0.049	0.869
	(0.062)	(0.053)	(0.060)	(0.038)	(0.070)		(0.054)	(0.051)	
Abnormal Cap. Ex.	0.052	0.092	0.064	0.081	0.108	0.425	0.086	0.092	0.848

Table 1 (continued)

Variable	Total	ZL	Proxy	*R*&D ZL	Non-*R*&D ZL	Diff.-in-Mean	ZL in high competition industries	ZL in low competition industries	Diff.-in-Mean
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	(0.754)	(0.891)	(0.842)	(0.886)	(0.876)		(0.887)	(0.867)	
Asset sale	0.028	0.052	0.036	0.059	0.034	0.000	0.058	0.042	0.027
	(0.088)	(0.124)	(0.104)	(0.129)	(0.094)		(0.127)	(0.108)	
Log(age)	2.432	2.302	2.283	2.275	2.364	0.179	2.230	2.410	0.010
	(0.529)	(0.512)	(0.516)	(0.504)	(0.521)		(0.500)	(0.511)	
Average No. of observations	2,613	319	675	218	101		190	129	

Column (1) reports the moving average of cross-sectional means, obtained by first calculating firm-level means for each year and then averaging across all years. Proxy firms are non-zero-leverage firms that are in the same three-digit SIC industry, in the same year, have a similar book value of total assets, and follow the same dividend payout policy as zero-leverage firms. Columns (6) and (9) report the p-values from difference-in-means tests between columns (4) and (5), and between columns (7) and (8), respectively. High (low) market competition industries are defined as those with a Compustat HHI below (above) the annual median. Standard errors are reported in parentheses. All continuous variables are winsorised at the 1 st and 99th percentiles. Detailed variable definitions are provided in the appendix

higher than for non-R&D firms.[6] These results have substantial economic significance, as increasing R&D investment is associated with a notable increase in the likelihood of becoming zero-leveraged.

The results for other control variables are broadly in line with expectations. For instance, smaller firms are more likely to be zero-leveraged, as indicated by the negative coefficients on firm size. A high market-to-book ratio increases the likelihood of zero leverage, possibly reflecting a preference for equity financing under favourable valuations. Profitability is positively associated with zero leverage, consistent with greater internal financing capacity. Lower tangibility reduces borrowing capacity, increasing the likelihood of zero leverage. While dividend-paying status has little effect, larger dividend payouts are linked to higher zero-leverage probability. Firms with more volatile earnings are also more likely to avoid debt, possibly due to heightened perceived risk.

R&D zero-leverage firms in our sample are significantly less profitable than their non-R&D counterparts, as shown in columns 4 to 6 of Table 1. This is consistent with Curtis et al. (2020) and Chen et al. (2021), who document that R&D enhanced firm profitability from the early 1980 s to the mid-1990s, after which profitability declined and stabilised at a lower level. They attribute this trend to factors such as changes in R&D investment patterns, the types of firms engaging in R&D, and diminishing marginal returns. Frank and Goyal (2015) further show that leverage decreases as profitability increases, supporting our findings in Table 2. To explore the channel through which R&D affects zero leverage, we split

[6] Among R&D firms, a one-decile increase in the R&D-to-assets ratio raises the probability of being zero-leveraged by 1.1%, while a similar increase in the R&D-to-sales ratio raises it by 1.9%. These additional results are available upon request. Overall, the R&D-to-assets ratio is the strongest predictor of zero-leverage status in the full sample, whereas the R&D-to-sales ratio has the highest predictive power among firms with positive R&D investment.

Table 2 The effect of R&D on zero-leverage decisions

Variable	Original coefficient			Marginal effect		
	Full sample	High profitability	Low profitability	Full sample		
	(1)	(2)	(3)	(4)	(5)	(6)
R&D-to-sales$_{i,t-1}$	0.189***			0.016***		
	(0.026)			(0.002)		
R&D-to-assets$_{i,t-1}$		0.882	1.008***		0.185***	
		(0.58)	(0.32)		(0.026)	
R&D dummy$_{i,t-1}$						0.014**
						(0.006)
Log (size)$_{i,t-1}$	−0.446***	−0.504***	−0.314***	−0.037***	−0.037***	−0.037***
	(0.020)	(0.03)	(0.03)	(0.002)	(0.002)	(0.002)
Market-to-book$_{i,t-1}$	0.163***	0.334***	−0.039	0.013***	0.012***	0.014***
	(0.016)	(0.03)	(0.02)	(0.001)	(0.001)	(0.001)
Profitability$_{i,t-1}$	1.859***			0.154***	0.152***	0.107***
	(0.154)			(0.013)	(0.013)	(0.012)
Tangibility$_{i,t-1}$	−3.039***	−3.011***	−2.572***	−0.252***	−0.243***	−0.244***
	(0.238)	(0.32)	(0.37)	(0.019)	(0.020)	(0.020)
Dividend payer$_{i,t-1}$	0.091	−0.016	0.206	0.008	0.008	0.008
	(0.085)	(0.12)	(0.14)	(0.007)	(0.007)	(0.007)
Dividend payout$_{i,t-1}$	15.537***	13.167***	21.214***	1.288***	1.317***	1.349***
	(1.433)	(1.79)	(2.78)	(0.119)	(0.119)	(0.119)
Earnings volatility$_{i,t-1}$	0.663*	−1.274*	0.632	0.055*	0.048	0.070**
	(0.358)	(0.68)	(0.44)	(0.030)	(0.030)	(0.029)
Ind. Frac. ZL$_{i,t-1}$	4.993	−4.242	4.787	0.414	0.520	0.514
	(5.260)	(7.58)	(7.00)	(0.436)	(0.435)	(0.438)
Init. ZL$_{i,t-1}$	1.191***	1.310***	1.021***	0.099***	0.099***	0.099***
	(0.077)	(0.12)	(0.09)	(0.006)	(0.006)	(0.006)
Capital expenditure$_{i,t-1}$	1.748***	3.172***	−1.014	0.145***	0.112***	0.127***
	(0.485)	(0.67)	(0.78)	(0.040)	(0.041)	(0.041)
Abnormal Cap. Ex.$_{i,t-1}$	−0.056***	−0.068**	−0.010	−0.005***	−0.004***	−0.004***
	(0.014)	(0.03)	(0.02)	(0.001)	(0.001)	(0.001)
Asset sales$_{i,t-1}$	2.192***	2.493***	1.440***	0.182***	0.179***	0.184***
	(0.166)	(0.35)	(0.21)	(0.014)	(0.014)	(0.014)
Log (age)$_{i,t-1}$	−0.033	0.036	−0.102	−0.003	−0.004	−0.005
	(0.048)	(0.08)	(0.06)	(0.004)	(0.004)	(0.004)
Pseudo R^2	0.24	0.26	0.20	0.24	0.24	0.23
No. of observations	91,681	28,583	24,472	91,681	92,154	92,154

This table presents the baseline regression results examining the impact of R&D on unlevered decisions. The dependent variable is a zero-leverage dummy that equals 1 if firm i is zero-leveraged in year t, and 0 otherwise. Columns (1) to (3) report the original logit coefficients and standard errors (in parentheses), while columns (4) to (6) report the average marginal effects and Delta-method standard errors. The high (low) profitability sample is defined as firms with profitability above the 70th percentile (below the 30th percentile) within a given industry and year. Industry and year fixed effects are included in all regressions. All standard errors in parentheses are heteroscedasticity-robust and clustered at the firm level. All continuous variables are winsorised at the 1 st and 99th percentiles. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

the sample by profitability and compare firms with high and low profitability in columns 2 and 3. To avoid mechanically controlling for the grouping variable, profitability is excluded from the regressions. We find that R&D has a significant positive effect on the probability of zero leverage only among low-profitability firms. This suggests that the R&D effect is concentrated in firms with limited internal resources, while highly profitable R&D firms are not more likely to be zero-leveraged.

Anzoategui et al. (2019) document that R&D activity may be influenced by business cycles, which affect financing costs in capital markets. We divide the sample into four periods using cut-off points in 1990, 2001, and 2007, corresponding to peak-to-peak business cycle turning points identified by the National Bureau of Economic Research (NBER). Subsample results in Table 3 reveal a consistent pattern: R&D does not appear to affect the likelihood of being zero-leveraged before 1990 (columns 1 and 5). This is consistent with the absence of an R&D boom and the limited role of R&D in capital structure decisions during that period. Between 1991 and 2001, the R&D-to-assets ratio has a highly significant positive effect on the probability of being zero-leveraged (column 2), although the R&D dummy remains insignificant (column 6). Since 2002, R&D has had a consistently significant and positive effect across both measures (columns 3, 4, 7, and 8). Overall, the results in Table 3 suggest that, after accounting for business cycle dynamics, the marginal effects of R&D have followed an upward trend over time in explaining zero-leverage decisions.

Overall, our findings indicate that R&D has a significant and positive effect on the likelihood of firms being zero-leveraged, and that this effect strengthens over time. Beyond its direct impact, R&D also influences zero-leverage decisions through the profitability channel, with the effect concentrated among firms with low profitability.

4.3 The impact of changes in R&D investment Vs R&D sensitivity

Brown et al. (2009) find that both aggregate R&D investment and the number of R&D-active firms increased sharply during periods of R&D booms. Consistent with this pattern, our results in Table 3 show that the impact of R&D on zero-leverage behaviour has strengthened over the same period. We identify two potential explanations for this increasing effect. First, the level of R&D investment has risen, making more firms adopt zero-leverage decisions. Second, the sensitivity of zero-leverage behaviour to R&D may have increased over time, implying that even if the scale of R&D investment had remained constant, its marginal impact would still have grown. To examine the relative contributions of these two channels, we follow He and Wintoki (2016) and decompose the R&D effect on the probability of adopting a zero-leverage policy into two components: (i) the changing factor effect, which reflects changes in the level of R&D investment, and (ii) the changing sensitivity effect, which captures changes in the responsiveness of zero-leverage behaviour to R&D.

To conduct the tests, we compare two equal-length periods, 1980–1992 and 2005–2017, with the former marking the end of the second R&D boom (Brown et al. 2009). Columns 1 to 4 of Table 4 report the means of all regression variables and the marginal effects of R&D from the logit model for each period. In Panel A, the mean R&D-to-assets ratio rises from 0.041 to 0.109, while the marginal effect of R&D on the probability of being zero-leveraged increases substantially from 0.078 (marginally significant) to 0.262 (highly significant) across the two periods.

We assume that the estimated R&D effects from the first period persist into the second period. The percentage change in the probability of being zero-leveraged due to factor changes is calculated as the difference in the mean of each variable between the two periods, multiplied by the average marginal effect (AME) from the first period, i.e. [mean (2005–2017) – mean (1980–1992)] × AME (1980–1992), and is expressed as a percentage. Since we hold marginal effects constant and allow only the means of firm characteristics to vary, the results in column 5 capture the contribution of the factor channel alone. For example, assuming the marginal effect of R&D from 1980 to 1992 (0.078) remains unchanged, the increase in the probability of being zero-leveraged due to a rise in the average R&D-to-assets ratio from 0.041 to 0.109 is (0.109–0.041) × 7.8% = 0.53%, as shown in column 5.

Similarly, to calculate the percentage change in the probability of being zero-leveraged arising from changes in sensitivity to explanatory variables, we hold the mean values of firm characteristics constant and allow only the average marginal effects (AMEs) to vary. This component is calculated as the mean of each variable in the first period multiplied by the change in its AME across the two periods, i.e. mean (1980–1992) × [AME (2005–2017) – AME (1980–1992)]. Accordingly, the values reported in column 6 capture the contribution of the sensitivity channel alone. For example, assuming the R&D-to-assets ratio remained constant at 0.041 (the mean in 1980–1992), the increase in the probability of being zero-leveraged due to changes in sensitivity to R&D is 0.041 × (0.262–0.078) = 0.75%, as shown in column 6.

Column 7 reports the sum of the values in columns 5 and 6. Specifically, changes in both R&D investment and the sensitivity of zero-leverage behaviour to R&D increased the probability of being zero-leveraged by 1.28% points from the 1980–1992 period to the 2005–2017 period. Over the same period, the actual proportion of zero-leverage firms in our sample rose by 12.82% points (from 6.76% to 19.58%). This implies that R&D-related factors account for approximately 10% of the observed increase in zero-leverage behaviour, with the factor channel contributing 4.1% (0.53/12.82) and the sensitivity channel contributing 5.9% (0.75/12.82). In Panel B, the explanatory power of the sensitivity channel (1.68%) is notably stronger than that of the factor channel (–0.09%) for the R&D dummy.

In summary, the results in both Panels A and B of Table 4 are highly consistent and indicate that the increase in sensitivity accounts for a larger share of the total rise in the impact of R&D on zero-leverage behaviour than the increase in R&D investment.

4.4 Market competition

It is also possible that both firms' R&D and financing behaviours are shaped by product market competition. R&D may enhance firms' comparative advantage when facing competitive threats, and firms may compete for access to external finance. We therefore investigate whether market competition directly influences zero-leverage behaviour and whether it interacts with R&D. Columns 7 to 9 of Table 1 present summary statistics for unleveraged firms in high- and low-competition industries, where competition is proxied by the Compustat HHI. Unleveraged firms in more competitive industries engage in substantially more R&D activity. However, they face greater challenges in survival compared to their counterparts in less competitive industries. Despite having stronger growth opportunities, these firms are on average smaller, less profitable, slightly less asset-intensive, pay lower

Table 3 The marginal effect of R&D on zero-leverage decision over business cycles

Variable	1980–1990	1991–2001	2002–2007	2008–2017	1980–1990	1991–2001	2002–2007	2008–2017
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D-to-assets$_{i,t-1}$	0.030	0.195***	0.206***	0.264***				
	(0.054)	(0.037)	(0.058)	(0.058)				
R&D dummy$_{i,t-1}$					−0.004	0.010	0.026**	0.034***
					(0.006)	(0.008)	(0.012)	(0.012)
Log (size)$_{i,t-1}$	−0.021***	−0.034***	−0.041***	−0.055***	−0.021***	−0.034***	−0.041***	−0.055***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Market-to-book$_{i,t-1}$	0.010***	0.013***	0.014***	0.012***	0.011***	0.015***	0.016***	0.016***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
Profitability$_{i,t-1}$	0.078***	0.152***	0.172***	0.212***	0.075***	0.108***	0.119***	0.146***
	(0.020)	(0.020)	(0.030)	(0.028)	(0.019)	(0.018)	(0.026)	(0.024)
Tangibility$_{i,t-1}$	−0.069***	−0.287***	−0.454***	−0.244***	−0.071***	−0.289***	−0.451***	−0.245***
	(0.020)	(0.029)	(0.046)	(0.037)	(0.020)	(0.029)	(0.047)	(0.037)
Dividend payer$_{i,t-1}$	0.012*	0.017	0.004	0.005	0.012*	0.016	0.004	0.004
	(0.007)	(0.010)	(0.016)	(0.015)	(0.007)	(0.010)	(0.016)	(0.015)
Dividend payout$_{i,t-1}$	0.891***	1.426***	1.662***	1.191***	0.885***	1.461***	1.699***	1.237***
	(0.118)	(0.196)	(0.302)	(0.213)	(0.118)	(0.197)	(0.305)	(0.217)
Earnings volatility$_{i,t-1}$	0.165***	−0.005	−0.020	0.122*	0.169***	0.025	−0.004	0.149**
	(0.040)	(0.050)	(0.063)	(0.064)	(0.040)	(0.048)	(0.063)	(0.063)
Ind. Frac. ZL$_{i,t-1}$	0.359	0.575	1.326	0.136	0.339	0.556	1.361	0.204
	(0.421)	(0.560)	(0.984)	(0.836)	(0.419)	(0.565)	(0.993)	(0.857)
Init. ZL$_{i,t-1}$	0.076***	0.095***	0.122***	0.100***	0.077***	0.096***	0.121***	0.101***
	(0.007)	(0.008)	(0.012)	(0.012)	(0.007)	(0.008)	(0.012)	(0.012)
Capital expenditure$_{i,t-1}$	−0.142***	0.183***	0.503***	0.227**	−0.139***	0.201***	0.519***	0.243**
	(0.049)	(0.054)	(0.119)	(0.100)	(0.049)	(0.054)	(0.120)	(0.100)
Abnormal Cap. Ex.$_{i,t-1}$	−0.006***	−0.003	−0.011***	0.003	−0.006***	−0.004*	−0.011***	0.003
	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)
Asset sales$_{i,t-1}$	0.014	0.167***	0.217***	0.278***	0.013	0.172***	0.219***	0.287***

Table 3 (continued)

Variable	1980–1990	1991–2001	2002–2007	2008–2017	1980–1990	1991–2001	2002–2007	2008–2017
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.030)	(0.025)	(0.026)	(0.030)	(0.030)	(0.025)	(0.026)	(0.030)
Log $(age)_{i,t-1}$	0.002	−0.013**	−0.001	0.002	0.002	−0.015***	−0.003	0.002
	(0.007)	(0.006)	(0.009)	(0.007)	(0.007)	(0.006)	(0.009)	(0.007)
Pseudo R^2	0.25	0.22	0.20	0.23	0.25	0.21	0.20	0.22
No. of observations	24,359	28,931	16,640	22,224	24,359	28,931	16,640	22,224

This table presents the average marginal effects of R&D from logit regressions, estimated separately for each business-cycle period. The dependent variable is the zero-leverage dummy. The variable of interest is R&D-to-assets in columns (1) to (4), and the R&D dummy in columns (5) to (8). Industry and year fixed effects are included in all regressions. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the firm level. See also the notes to Table 2

Table 4 Decomposition of the increase in the probability of adopting zero-leverage policies

Variable	Mean	Mean	AME	AME	Changing factor	Changing sensitivity	Total
	1980–1992	2005–2017	1980–1992	2005–2017			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. R&D measured by R&D-to-assets							
R&D-to-assets$_{i,t-1}$	0.041	0.109	0.078*	0.262***	0.53%	0.75%	1.28%
Log (size)$_{i,t-1}$	3.963	4.702	−0.023***	−0.052***	−1.70%	−11.53%	−13.23%
Market-to-book$_{i,t-1}$	2.178	2.62	0.012***	0.012***	0.51%	0.14%	0.65%
Profitability$_{i,t-1}$	0.121	−0.015	0.081***	0.208***	−1.11%	1.53%	0.42%
Tangibility$_{i,t-1}$	0.222	0.128	−0.090***	−0.284***	0.85%	−4.31%	−3.46%
Dividend payer$_{i,t-1}$	0.438	0.215	0.015**	0.005	−0.32%	−0.40%	−0.73%
Dividend payout$_{i,t-1}$	0.019	0.012	0.959***	1.245***	−0.67%	0.54%	−0.13%
Earnings volatility$_{i,t-1}$	0.082	0.115	0.160***	0.090	0.53%	−0.58%	−0.05%
Ind. Frac. ZL$_{i,t-1}$	0.133	0.169	0.331	0.484	1.19%	2.03%	3.22%
Init. ZL$_{i,t-1}$	0.535	0.449	0.081***	0.106***	−0.70%	1.34%	0.65%
Capital expenditure$_{i,t-1}$	0.063	0.036	−0.115**	0.292***	0.31%	2.56%	2.87%
Abnormal Cap. Ex.$_{i,t-1}$	0.059	0.139	−0.006***	0.001	−0.04%	0.04%	0.00%
Assets sale$_{i,t-1}$	0.022	0.073	0.023	0.264***	0.12%	0.53%	0.65%
Log (age)$_{i,t-1}$	1.547	2.187	−0.007	0.000	−0.45%	1.03%	0.58%
No. of observations	29,125	30,213	29,125	30,213			
Panel B. R&D measured by R&D dummy							
R&D dummy$_{i,t-1}$	0.463	0.669	−0.004	0.032***	−0.09%	1.68%	1.59%
Log (size)$_{i,t-1}$	3.963	4.702	−0.023***	−0.052***	−1.69%	−11.68%	−13.37%
Market-to-book$_{i,t-1}$	2.178	2.62	0.012***	0.016***	0.55%	0.69%	1.24%
Profitability$_{i,t-1}$	0.121	−0.015	0.073***	0.142***	−0.99%	0.83%	−0.16%
Tangibility$_{i,t-1}$	0.222	0.128	−0.093***	−0.284***	0.87%	−4.24%	−3.37%
Dividend payer$_{i,t-1}$	0.438	0.215	0.014**	0.004	−0.32%	−0.44%	−0.76%
Dividend payout$_{i,t-1}$	0.019	0.012	0.954***	1.291***	−0.67%	0.64%	−0.03%
Earnings volatility$_{i,t-1}$	0.082	0.115	0.168***	0.113**	0.55%	−0.45%	0.10%
Ind. Frac. ZL$_{i,t-1}$	0.133	0.169	0.301	0.540	1.08%	3.17%	4.26%
Init. ZL$_{i,t-1}$	0.535	0.449	0.082***	0.106***	−0.70%	1.30%	0.59%
Capital expenditure$_{i,t-1}$	0.063	0.036	−0.110**	0.307***	0.30%	2.62%	2.92%
Abnormal Cap. Ex.$_{i,t-1}$	0.059	0.139	−0.006***	0.001	−0.04%	0.04%	−0.01%
Assets sale$_{i,t-1}$	0.022	0.073	0.020	0.273***	0.10%	0.56%	0.66%
Log (age)$_{i,t-1}$	1.547	2.187	−0.008	−0.001	−0.48%	1.01%	0.53%
No. of observations	29,125	30,213	29,125	30,213			

This table decomposes the increase in the aggregate probability of adopting a zero-leverage decision into changes in firm characteristics (changing factors) and changes in sensitivity (changing sensitivities). Columns (3) and (4) present the average marginal effects of the regression in Eq. (2) for being zero-leverage firms during 1980–1992 and 2005–2017, respectively. The percentage change in the aggregate probability of being zero-leverage firms arising from the changing factors is reported in column (5), calculated as [Mean(2005–2017) - Mean(1980–1992)]×AME(1980–1992). The percentage change due to the changing sensitivities is reported in column (6), calculated as Mean(1980–1992)×[AME(2005–2017) - AME(1980–1992)]. Column (7) reports the total effect, which is the sum of the values in columns (5) and (6). Industry and year fixed effects are included in all the regressions. Delta-method standard errors (in parentheses) are adjusted for heteroscedasticity and clustered at firm level. Also see notes to Table 2

dividends, experience greater earnings volatility, and rely more on asset sales. These characteristics make them less attractive to lenders.

Figure 2 plots the proportion of zero-leverage firms in high- and low-competition industries over time. Prior to 1995, both groups exhibit similar levels and trends in zero-leverage behaviour. After 1995, however, a clear divergence emerges: the share of zero-leverage firms continues to rise in high-competition industries, while it remains largely flat in low-competition industries. Notably, this turning point coincides with the R&D boom documented by Brown et al. (2009).

We next include HHI as an explanatory variable in Eq. (2) and estimate the model for the full sample and for subsamples split at major recession points, following the approach in Table 3. The results are presented in Panel A of Table 5. The coefficients on the Compustat HHI are negative and statistically significant for the full sample and several subsamples, indicating that greater market competition increases the likelihood of firms being zero-leveraged. A plausible mechanism is the profitability channel: increased competition may reduce profitability, thereby restricting access to debt financing. As in Table 2, we examine this mechanism further by splitting the sample based on profitability (columns 2 and 3). The negative effect of HHI on the probability of zero leverage is only present among low-profitability firms, suggesting that market competition drives zero-leverage behaviour primarily when firms are financially constrained.

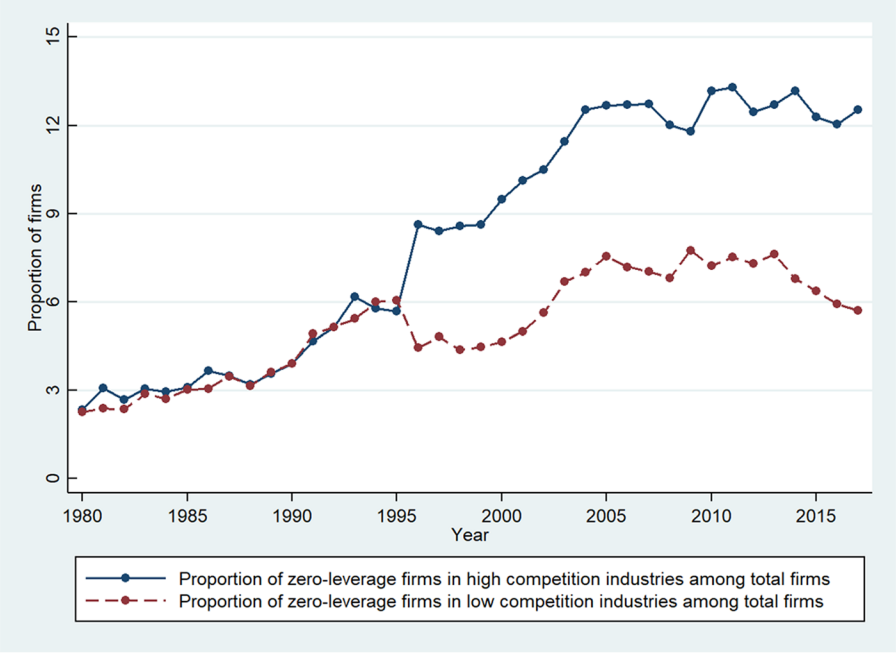


Fig. 2 The proportion of zero-leverage firms by the level of market competition they face. The solid line shows the proportion of zero-leverage firms in the high competition industries over the total number of firms in each year, and the dashed line the ratio for zero-leverage firms in the low competition industries. High (low) market competition industry is defined as an industry's Compustat HHI which is lower (higher) than the median Compustat HHI in a year. Source: Authors' own calculation

Table 5 The effect of market competition on zero-leverage decisions

Variable	Full sample	High profitability	Low profitability	Full sample			
				1980–1990	1991–2001	2002–2007	2008–2017
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. Full sample							
Compustat $HHI_{i,t-1}$	−0.053***	−0.035	−0.068***	−0.018	−0.058**	−0.102***	−0.060**
	(0.016)	(0.024)	(0.025)	(0.017)	(0.024)	(0.037)	(0.028)
R&D-to-$assets_{i,t-1}$R&D-to-$assests_{i,t-1}$	0.196***	0.094*	0.116***	−0.004	0.211***	0.248***	0.285***
	(0.026)	(0.052)	(0.030)	(0.053)	(0.036)	(0.056)	(0.056)
Pseudo R_2	0.23	0.25	0.19	0.24	0.20	0.19	0.22
No. of observations	92,154	28,583	24,472	24,359	28,931	16,640	22,224
Panel B. Compustat HHI for R&D sample							
Compustat $HHI_{i,t-1}$	−0.090***	−0.043	−0.122***	0.010	−0.106**	−0.191***	−0.144***
	(0.029)	(0.041)	(0.046)	(0.025)	(0.255)	(0.068)	(0.048)
R&D-to-$assets_{i,t-1}$	0.248***	0.055	0.150***	0.082	0.045***	0.267***	0.336***
	(0.035)	(0.066)	(0.044)	(0.054)	(0.052)	(0.078)	(0.078)
Pseudo R_2	0.25	0.27	0.20	0.27	0.24	0.18	0.21
No. of observations	43,196	13,508	11,537	10,637	13,103	8,388	11,068
Panel C. Compustat HHI for non-R&D sample							
Compustat $HHI_{i,t-1}$	−0.019	−0.023	−0.016	−0.041**	−0.030	−0.028	0.022
	(0.016)	(0.028)	(0.024)	(0.020)	(0.024)	(0.036)	(0.030)
Pseudo R_2	0.20	0.24	0.17	0.26	0.17	0.18	0.21
No. of observations	48,958	15,075	12,935	13,722	15,828	8,252	11,156

This table presents the average marginal effects of market competition from logit regressions. The dependent variable is the zero-leverage dummy. Panels A, B, and C report the results using the full sample, the sample of R&D firms, and the sample of non-R&D firms, respectively. R&D firms are defined as firms with non-zero R&D expenses in a given year. Columns (4) to (7) present the results separately for each business-cycle period. All regressions include the control variables from Table 2 and year fixed effects. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the firm level. See also the notes to Table 2

When the HHI variable is included, the coefficients on the R&D-to-assets ratio remain highly consistent with the results in Tables 2 and 3. We then divide the sample into R&D and non-R&D firm-years in Panels B and C, respectively, and re-estimate the model as in Panel A. The results remain consistent: market competition significantly increases the probability of zero leverage among R&D firms (Panel B), but not among non-R&D firms (Panel C). This effect is further concentrated in less profitable R&D firms (columns 2 and 3).

We also employ several alternative proxies for market competition to verify the robustness of our findings, including the price-cost margin, instrumented import penetration, Textual Network Industry Classification-based HHI (THHI), and fitted HHI (FHHI). When market competition intensifies and the supply of similar products rises, firms lower prices to attract consumers. As prices converge towards marginal cost, the price-cost margin declines (Bresnahan and Reiss 1991). Following Acemoglu et al. (2016) and Lie and Yang (2023), we construct instrumented import penetration by instrumenting Chinese import penetration in the US with that in other high-income countries. THHI is a firm-level competition measure derived from text-based analysis of 10-K product descriptions, based on the number of common words in firms' product disclosures (Hoberg and Phillips 2010b, 2016). FHHI is an industry-level measure that captures market competition across both private and public firms (Hoberg and Phillips 2010b). Higher competition is reflected in a lower price-cost margin, lower THHI and FHHI, and higher import penetration.

Table 6 presents the regression results using alternative proxies for market competition, including the price-cost margin, instrumented import penetration, THHI, and FHHI. Consistent with our main findings, the results show that the price-cost margin, THHI, and FHHI are significantly and negatively associated with the probability of being zero-leveraged, while import penetration has a significant positive effect.

Therefore, our results suggest that market competition induces zero-leverage behaviour, with the effect primarily concentrated among low-profitability R&D firms. This finding also explains the sharp divergence in zero-leverage prevalence between firms operating in high-

Table 6 Robustness tests -alternative proxies of market competition

	(1)	(2)	(3)	(4)
Price-cost margin$_{i,t-1}$	−0.005***			
	(0.002)			
Instrumented import penetration$_{i,t-1}$		0.096**		
		(0.042)		
THHI$_{i,t-1}$			−0.065***	
			(0.013)	
FHHI$_{i,t-1}$				−0.365**
				(0.152)
Pseudo R^2	0.24	0.21	0.22	0.24
N.	91,681	22,230	51,187	59,832

This table presents the average marginal effects of alternative proxies for market competition from logit regressions. The dependent variable is the zero-leverage dummy. The price-cost margin is proxied by the gross profit margin, calculated as the difference between total sales and cost of goods sold, divided by total sales. Instrumented Import Penetration captures foreign competition using Chinese imports in other high-income countries as an instrument. THHI is a modified Herfindahl index based on textual similarity in product descriptions from 10-K filings. FHHI is the HHI that includes both public and private firms. All regressions include the control variables from Table 2. Column (1) includes year and industry fixed effects, while columns (2) to (4) include year fixed effects only. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the firm level. See also the notes to Table 2

and low-competition industries observed in Fig. 2. Prior to the 1995 R&D boom (Brown et al. 2009), market competition had limited effect on the probability of being zero-leveraged. Since then, however, it has become a key determinant of zero-leverage behaviour through its interaction with R&D. Both R&D and market competition have contributed to declining profit margins (Curtis et al. 2020; Xu 2012), which in turn are associated with lower leverage, consistent with the trade-off theory (Xu 2012).

4.5 Additional robustness tests

It is possible that our findings are influenced by the persistence of zero-leverage behaviour, managerial and board characteristics, or macroeconomic conditions. To address these concerns, we re-estimate our models with additional control variables. First, since past zero-leverage status may affect current decisions, we include a lagged indicator of zero leverage. Second, to account for the potential influence of managerial attributes on financing and innovation choices, we incorporate CEO and board characteristics obtained from BoardEx, including CEO tenure, CEO gender, the logarithm of board size, the proportion of female directors, and the proportion of independent directors. Finally, to control for macroeconomic conditions, we include the GDP growth rate, interest rate, and inflation.

Table 7 presents the corresponding results. Columns 1, 3, and 5 show that the coefficients on R&D remain positive and significant after including additional control variables, supporting the hypothesis that R&D investment is positively associated with zero-leverage behaviour. Similarly, columns 2, 4, and 6 indicate that higher market competition is associated with a greater likelihood of firms being zero-leveraged.

In untabulated analyses, we also examine whether our findings hold for almost zero-leverage firms. The results remain consistent: both R&D and market competition significantly increase the likelihood of firms adopting extremely conservative debt policies. However, the effect of market competition is only present among R&D firms, and not among non-R&D firms.[7] Overall, the robustness checks provide supportive evidence for the validity of our baseline results.

5 Exogenous policy shocks

In this section, we test the causal effects of R&D and market competition on zero-leverage behaviour by exploiting two sets of policy shocks within a difference-in-differences framework.

5.1 The R&D tax credit shocks

In response to the technology-driven economic success of Japan and South Korea, the US introduced the Economic Recovery Tax Act of 1981, which offered federal tax credits for firms' R&D expenditures (Bloom et al. 2002). A substantial body of literature has since documented the effectiveness of R&D tax incentives in increasing firms' R&D intensity (e.g., Hall 1993; Bloom et al. 2002; Wilson 2009). In the following years, many US states independently enacted or expanded their own R&D tax credit schemes, generating a stag-

[7] The results are available upon request.

Table 7 Robustness tests - Including additional control variables

Variable	Lagged ZL decision		CEO and board characteristics		Macroeconomic conditions	
	(1)	(2)	(3)	(4)	(5)	(6)
R&D-to-assetsi,t-1	0.055***		0.219***		0.185***	
	(0.010)		(0.055)		(0.026)	
Compustat HHIi,t-1		−0.013***		−0.076***		−0.032**
		(0.005)		(0.028)		(0.016)
ZLi,t-1	0.176***	0.178***				
	(0.001)	(0.001)				
Log(board size)$_{i,t-1}$			−0.075***	−0.082***		
			(0.022)	(0.022)		
CEO tenure$_{i,t-1}$			0.001	0.001		
			(0.001)	(0.001)		
Independent director$_{i,t-1}$			−0.063*	−0.091***		
			(0.033)	(0.034)		
CEO gender$_{i,t-1}$			0.064***	0.072***		
			(0.020)	(0.021)		
Female director$_{i,t-1}$			0.025	0.000		
			(0.051)	(0.051)		
GDP growth$_{i,t-1}$					0.268	0.278
					(0.343)	(0.340)
Interests rate$_{i,t-1}$					−0.017***	−0.018***
					(0.006)	(0.006)
Inflation$_{i,t-1}$					0.008	0.008
					(0.005)	(0.005)
Pseudo R_2	0.59	0.58	0.26	0.23	0.24	0.23
N.	92,154	92,154	29,318	29,318	92,154	92,154

This table presents the average marginal effects of R&D and market competition from estimations that include additional control variables. The dependent variable is the zero-leverage dummy. All regressions include the control variables from Table 2. Columns (1), (3), and (5) include year and industry fixed effects, while columns (2), (4), and (6) include year fixed effects only. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the firm level. See also the notes to Table 2

gered policy rollout across states. When a state adopts a new or more generous credit, firms located in that state experience a sudden drop in the after-tax cost of R&D, creating plausibly exogenous variation in R&D incentives. Crucially, these changes are not driven by firm-level actions or performance, allowing for a quasi-experimental setting.

The key identification assumption is that state-level R&D tax credits are broadly applied across firms and that the timing of their implementation is unrelated to specific firm characteristics. This view is supported by prior research, which finds that the generosity and timing of state R&D tax credits appear largely idiosyncratic or effectively random from the perspective of individual firms (e.g., Bloom et al. 2013; Hombert and Matray 2018). Importantly, these staggered policy shocks allow us to study how exogenous changes in R&D incentives influence firms' financing behaviour, particularly their adoption of zero-leverage policies. Given that R&D-intensive firms are typically more financially constrained and rely less on debt, this setting provides a quasi-experimental context for assessing the causal effect of R&D incentives on zero-leverage decisions.

We obtain information on the states that introduced R&D tax credit policies and their implementation years from Falato and Sim (2014). Based on their classification, we identify 38 states that enacted such policies between 1983 and 2011. Firms headquartered in states that implemented R&D tax credits are assigned to the treatment group, while those in non-adopting states form the control group.

To account for potential differences in firm characteristics between the two groups, we implement a propensity score matching (PSM) approach. Specifically, we estimate a logit model in which the dependent variable is a treatment group indicator, and the independent variables include commonly used determinants of capital structure: firm size, age, market-to-book ratio, profitability, capital expenditure, dividend payer status, and initial zero-leverage status. The estimated propensity score is the predicted probability from this regression. Each treated firm is then matched to a control firm in the same year with the closest propensity score, within a caliper of 1%, and located in a state that had not implemented an R&D tax credit in the same year.[8] Using this approach, we identify 1,817 matched control firms for 2,703 treated firms in the full sample, 739 matched R&D control firms for 1,219 treated R&D firms, and 1,078 matched non-R&D control firms for 1,484 treated non-R&D firms.

We estimate the following logit model for our DID test:

$$Pr\,(ZL) = \beta_0 + \beta_1 Treat_i + \beta_2 Post_{i,t} + \beta_3 Treat_i \times Post_{i,t} + Control\ variables_{i,t-1} + \upsilon_t + \upsilon_j + \upsilon_s + \epsilon_{i,t}, \quad (3)$$

$Treat_i$ is a dummy variable equal to one if firm i is affected by the policy shock, i.e., located in a state that implements an R&D tax credit policy, and zero otherwise. $Post_{i,t}$ is a dummy variable equal to one if a state has experienced the implementation of the R&D tax credit policy shock, and zero otherwise. The interaction term $Treat_i \times Post_{i,t}$ captures the causal effect of the R&D tax credit implementation on the zero-leverage decision of the treated firms. $Control\ variables_{i,t-1}$ are exactly the same as the control variables in Table 2. υ_t, υ_s and υ_j are time, state, and industry dummies, respectively. Given that the variation in the implementation of R&D tax credit policy is at the state level, we use robust standard errors clustered by state to control for dependence in the error terms for firms in the same state.

Table 8 reports the DID results. For the full, R&D, and non-R&D samples, we use data from three years before and after the policy shock to better isolate the causal impact of the R&D tax credit. In the full sample, β_3 is significantly positive, with a value of 0.019 in column 1. This suggests that the probability of being zero-leveraged increases by 1.9% more for treated firms than for matched control firms after the introduction of the R&D credit. Column 4 shows an even stronger effect in the R&D subsample, where the probability of treated firms being zero-leveraged increases by 4.3%. In contrast, β_3 is statistically insignificant in the non-R&D subsample, as shown in column 7, indicating that the implementation of the R&D tax credit does not affect zero-leverage behaviour among non-R&D firms.

We also follow Park et al. (2019) and include $Pre - trend_{i,t-n}$, which is an interaction term between a dummy variable indicating n fiscal years prior to the adoption of R&D tax

[8] We use a replacement procedure that when multiple treatment firms match the same control firm that has the closest propensity score, we may select a control firm more than once. Such replacement procedure can always match the treated firms to the closest control firms. Therefore, it reduces bias and produces more balance than matching without the replacement procedure. The replacement condition can also make the order of the matching procedure irrelevant, whereas the result generated by matching without the replacement depends on the order that each match occurs (Caliendo and Kopeinig 2008).

Table 8 DID tests using R&D tax credit policy

Variable	Full sample			*R*&D sample			Non-*R*&D sample		
	[+3,−3]	Pre-trend	Placebo	[+3,−3]	Pre-trend	Placebo	[+3,−3]	Pre-trend	Placebo
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Post_{i,t}$	−0.013	−0.013	0.001	−0.025	−0.026	0.006	−0.012	−0.012	−0.002
	(0.011)	(0.011)	(0.008)	(0.016)	(0.016)	(0.012)	(0.018)	(0.017)	(0.012)
$Treat_i$	−0.061***	−0.065***	−0.072***	−0.124***	−0.127***	−0.114***	−0.000	−0.005	−0.013
	(0.014)	(0.014)	(0.021)	(0.024)	(0.024)	(0.036)	(0.017)	(0.017)	(0.016)
$Post_{i,t} \times Treat_i$	0.019*	0.019*		0.043***	0.040**		0.007	0.009	
	(0.011)	(0.011)		(0.016)	(0.016)		(0.014)	(0.014)	
$Pre\text{-}trend_{i,t-1}$		0.004			0.008			0.001	
		(0.005)			(0.008)			(0.004)	
$Pre\text{-}trend_{i,t-2}$		0.003			−0.002			0.006	
		(0.004)			(0.009)			(0.004)	
Placebo (−2)			0.005			0.003			0.006
			(0.006)			(0.010)			(0.007)
Pseudo	0.25	0.25	0.25	0.29	0.29	0.29	0.23	0.23	0.23
N.	17,297	17,297	13,018	7,363	7,363	5,605	9,669	9,669	7,144

This table reports the average marginal effects of R&D tax credit policies from the DID analysis. The sample is from 1983 to 2011. The dependent variable is the zero-leverage dummy. All regressions include the control variables from Table 2. $Pre-trend_{i,t-1}$ ($Pre-trend_{i,t-2}$) is a dummy variable set to one if a firm is headquartered in a state that will implement the R&D tax credit policy after one year (two years), and zero otherwise. Columns (3), (6), and (9) report the placebo tests, where the timing of the policy shock is falsely set two years in advance. All regressions include year, state, and industry fixed effects. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the state level. See also the notes to Table 2

credit policies and the treatment dummy. A significant $Pre-trend_{i,t-n}$ indicates that the divergence in the probability of being zero-leverage between the treated and control groups already exists before the policy shock, thereby implying a violation of the parallel assumption. Columns 2, 5 and 8 of Table 8 show insignificant coefficients on the pre-treatment trends for each sample, suggesting that our DID results are not driven by pre-existing differences in trends.

Finally, we conduct placebo tests for each of the samples to further assess the robustness of our results. Following He and Wintoki (2016), we artificially assign the policy shocks to two years prior to the actual implementation and find no significant effects for treated firms following these placebo shocks, as shown in columns 3, 6, and 9. This further supports the conclusion that our results are indeed driven by the actual implementation of the R&D tax credit policies.

Overall, our DID results show that, following the implementation of the R&D tax credit policies, treated firms are significantly more likely to adopt zero-leverage policies compared to matched control firms, with the effect being more pronounced among R&D firms. This pattern is not observed for non-R&D firms. These findings provide evidence consistent with a positive causal relationship between R&D incentives and firms' zero-leverage behaviour.

5.2 The import tariff shocks for market competition

The U.S. has implemented various tariff policies to influence industrial competition. Prior studies have extensively documented that reductions in tariff rates lower trade barriers and increase competition from foreign rivals (e.g., Valta 2012; Xu 2012; Frésard and Valta 2016). The underlying intuition is that lowering import tariffs exposes domestic firms to intensified foreign competition by facilitating the entry of foreign goods into the domestic market.

These policy changes are typically beyond the control of individual firms and are driven by geopolitical and macroeconomic considerations rather than firm-level lobbying or performance. Importantly, the extent to which industries are affected varies depending on pre-policy tariff schedules, many of which were established decades earlier (Pierce and Schott 2016; Huang et al. 2017). As such, tariff reductions are considered exogenous to firm characteristics, as they are not determined by individual firms' strategic decisions (Xu 2012; Hombert and Matray 2018).

One potential limitation of this identification strategy is that the threshold level of tariff reduction required to generate economically meaningful competitive pressure is not directly observable. To address this issue, we follow Valta (2012) and Frésard and Valta (2016) in defining a "large tariff reduction" as one that is at least three times greater than the industry's average change.

We utilise import tariff reductions at the industry level as exogenous shocks to market competition and employ a DID approach to further investigate the effects of competition policies. Tariff rate data at the 4-digit SIC industry level and the years of large tariff reductions are obtained from Frésard and Valta (2016), who identify 74 affected manufacturing industries between 1972 and 2005. We define a treatment dummy equal to one if a firm operates in an industry affected by a large tariff reduction, and zero otherwise. We then apply the same propensity score matching procedure as described in Sect. 5.1 to identify matched control firms.

We then conduct the DID tests in Eq. (3) following the same procedure used in Sect. 5.1, and report the results in Table 9. The coefficients on the interaction term $Treat_i \times Post_{i,t}$ are consistently positive and significant for both the full sample and the R&D sample, but insignificant for the non-R&D sample. These results suggest that tariff reductions have increased the probability of being zero-leveraged among treated R&D firms relative to their matched controls, but not among non-R&D firms. Furthermore, the insignificant coefficients on the pre-treatment trend variables and placebo tests support the validity of the parallel trends assumption and confirm the robustness of the findings. Overall, the DID results indicate that market competition policies positively affect firms' zero-leverage behaviour, and that this effect is primarily driven by firms engaged in R&D.

In addition, we employ the DID framework to explore cross-sectional heterogeneity in the effects across different types of firms. Specifically, we compare the impact between firms with high versus low growth opportunities, young versus established firms, small versus large firms, and firms with high versus low profitability. Table 10 reports the corresponding results.

We find that the effect of competition shocks on zero-leverage behaviour is more pronounced among R&D firms that are small and have low profitability. This finding is consistent with the view that R&D becomes less profitable under intense competition, thereby limiting firms' borrowing capacity (Hovakimian et al. 2001; Hoberg and Phillips 2010a; Xu 2012; Curtis et al. 2020; Chen et al. 2021).

For non-R&D firms, we observe that high competition has a stronger effect on younger firms with high investment opportunities. A potential explanation is that firms lacking innovation are more vulnerable to predatory rivalry in competitive environments (Chevalier 1995; Frésard 2010). As a result, young and high-growth non-R&D firms may deliberately avoid debt to preserve financial flexibility and protect themselves from predatory competition.

6 Conclusion

Due to their distinct financial strategies and unique position in terms of financial flexibility and risk management, zero-leverage firms deviate from the predictions of traditional financial theories and pose significant challenges for policymakers. In this study, we examine whether R&D tax credit policies and import tariff policies have contributed to the rise of zero-leverage firms in the US.

Consistent with our hypotheses, DID analyses provide evidence consistent with a causal interpretation of the effects of R&D incentives and market competition on firms' zero-leverage behaviour. We find that two-thirds of zero-leverage firms are R&D-intensive, and that R&D alone could explain approximately 10% of the observed increase in unlevered propensity. The R&D tax credit policies not only lead to greater R&D investment, but also increase the sensitivity of firms' capital structure choices to R&D, both of which contribute to the upward trend in zero-leverage firms. Moreover, the explanatory power of R&D has strengthened over time.

We also document a strong interaction effect between market competition and R&D on zero-leverage behaviour, particularly after 1990. These results are robust to a variety of alternative definitions of zero leverage, R&D intensity, and market competition, as well as

Table 9 DID tests using reductions of import tariff rates

Variable	Full sample			*R*&D sample			Non-*R*&D sample		
	[+3,−3]	Pre-trend	Placebo	[+3,−3]	Pre-trend	Placebo	[+3,−3]	Pre-trend	Placebo
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Post_{i,t}$	−0.043**	−0.041**	−0.020*	−0.064**	−0.061**	−0.028*	−0.000	−0.002	0.019
	(0.019)	(0.019)	(0.012)	(0.026)	(0.026)	(0.016)	(0.029)	(0.029)	(0.027)
$Treat_i$	−0.066***	−0.056**	−0.042***	−0.084***	−0.071**	−0.049***	−0.036	−0.045	−0.038
	(0.023)	(0.023)	(0.015)	(0.027)	(0.028)	(0.018)	(0.027)	(0.034)	(0.028)
$Post_{i,t} \times Treat_i$	0.043*	0.038*		0.065**	0.059**		−0.015	−0.008	
	(0.022)	(0.022)		(0.029)	(0.029)		(0.038)	(0.037)	
$Pre\text{-}trend_{i,t-1}$		0.000			0.000			−0.005	
		(0.007)			(0.008)			(0.024)	
$Pre\text{-}trend_{i,t-2}$		−0.015			−0.019			0.014	
		(0.009)			(0.011)			(0.017)	
Placebo (−2)			0.019			0.023			0.019
			(0.017)			(0.022)			(0.029)
Pseudo R^2	0.27	0.27	0.27	0.24	0.24	0.24	0.48	0.51	0.48
N.	4,485	4,485	3,392	3,252	3,252	2,510	811	811	568

This table reports the average marginal effects of large tariff reductions from the DID analysis. The dependent variable is the zero-leverage dummy. All regressions include the control variables from Table 2. The sample consists of manufacturing firms from 1980 to 2005. All regressions include year and industry fixed effects. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the four-digit SIC industry level. See also the notes to Tables 2 and 8

Table 10 Cross-sectional tests for the impact of tariff reductions

	R&D sample				Non-*R*&D sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Post_{i,t}$	−0.065*	−0.042	0.014	0.008	0.083	0.017	0.028	0.009
	(0.036)	(0.032)	(0.048)	(0.033)	(0.051)	(0.033)	(0.053)	(0.039)
$Treat_i$	−0.097***	−0.080***	0.021	0.027	0.002	−0.011	−0.012	0.011
	(0.031)	(0.030)	(0.041)	(0.029)	(0.052)	(0.030)	(0.052)	(0.040)
$Post_{i,t}$×$Treat_i$	0.041	0.019	−0.048	−0.033	−0.107	−0.034	−0.005	−0.004
	(0.041)	(0.039)	(0.054)	(0.038)	(0.070)	(0.039)	(0.061)	(0.046)
$Post_{i,t}$×$Treat_i$×High $growth_{i,t-1}$	0.019				0.146*			
	(0.052)				(0.086)			
$Post_{i,t}$×High $growth_{i,t-1}$	−0.015				−0.102			
	(0.043)				(0.063)			
$Treat_i$×High $growth_{i,t-1}$	0.061				−0.007			
	(0.039)				(0.068)			
High $growth_{i,t-1}$	−0.018				0.073			
	(0.033)				(0.061)			
$Post_{i,t}$×$Treat_i$×High $growth_{i,t-1}$		−0.060				0.454***		
		(0.051)				(0.103)		
$Post_{i,t}$×Young $firm_{i,t-1}$		0.062				−0.561***		
		(0.041)				(0.104)		
$Treat_{i,t}$×Young $firm_{i,t-1}$		−0.034				−0.509***		
		(0.039)				(0.095)		
Young $firm_{i,t-1}$		−0.044				0.558***		
		(0.036)				(0.098)		
$Post_{i,t}$×$Treat_i$×Small $firm_{i,t-1}$			0.115*				−0.036	
			(0.061)				(0.083)	
$Post_{i,t}$×Small $firm_{i,t-1}$			−0.098*				−0.011	
			(0.051)				(0.065)	
$Treat_i$×Small $firm_{i,t-1}$			−0.086*				0.008	

Table 10 (continued)

	R&D sample				Non-*R*&D sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			(0.048)				(0.067)	
$\text{Small firm}_{i,t-1}$			0.150***				0.017	
			(0.044)				(0.059)	
$\text{Post}_{i,t}\times\text{Treat}_i\times\text{Low profitability}_{i,t-1}$				0.110**				−0.081
				(0.052)				(0.087)
$\text{Post}_{i,t}\times\text{Low profitability}_{i,t-1}$				−0.099**				0.051
				(0.043)				(0.061)
$\text{Treat}_i\times\text{Low profitability}_{i,t-1}$				−0.112***				−0.035
				(0.041)				(0.065)
$\text{Low profitability}_{i,t-1}$				0.059				−0.054
				(0.037)				(0.054)
Pseudo R^2	0.28	0.29	0.29	0.29	0.50	0.48	0.48	0.5
N.	3,252	3,252	3,252	3,252	811	811	811	811

This table reports the average marginal effects of large tariff reductions interacted with growth opportunities, firm size, firm age, and profitability, based on the DID analysis. The dependent variable is the zero-leverage dummy. *High growth* is a dummy variable that equals one if a firm's market-to-book is above the median in a given year. *Young firm*, *Small firm*, and *Low profitability* are dummy variables that equal one if a firm's age, size, or profitability, respectively, is below the median in a given year. All regressions include the control variables from Table 2, as well as year and industry fixed effects. Delta-method standard errors (in parentheses) are heteroscedasticity-robust and clustered at the four-digit SIC industry level. See also the notes to Tables 2 and 9

additional controls and subsample analyses. Overall, our findings suggest that US R&D tax credit and import tariff policies are key drivers of the zero-leverage phenomenon, operating through the channels of innovation and product market competition.

Our foremost contribution is the identification of two interrelated policy drivers—R&D incentives and trade liberalisation—that contribute to the sharp rise in zero-leverage behaviour among US firms. Our findings offer new insights into how innovation and competition policies jointly influence corporate financial strategies, with important implications for policymakers. While R&D tax credit policies are designed to stimulate innovation and enhance productivity, they have also unintentionally led R&D-intensive firms to adopt zero-leverage policies. This raises concerns about potential under-leveraging, inefficiencies in capital allocation, and constrained long-term growth.

In contrast, our findings suggest that the recent sharp increases in US import tariffs, particularly those targeting Chinese imports, which reduce foreign competitive pressure on domestic firms, may lower the likelihood of firms adopting zero-leverage policies and promote more balanced, growth-oriented capital structures. These results provide support for current US tariff policies from a corporate finance perspective. They highlight an important but often overlooked benefit of trade protection: its potential to ease domestic firms' financing constraints and enhance the conditions for sustainable innovation and long-term growth. As such, trade policy may serve as a complementary instrument to R&D tax incentives in fostering an innovation-driven economy, provided it is carefully designed to balance protection with market competition. This perspective invites further investigation into how coordination between trade and innovation policies may better promote domestic firms' resilience, efficient capital allocation, and growth potential in a changing global landscape.

Appendix 1. Variable definitions

The abbreviations in the parentheses are the variable names in Compustat.

Book leverage: (long-term debt + short-term debt)/total assets ((DLC+DLTT)/AT).

Zero-leverage firms: zero-leverage firms are firms with zero book leverage in a year.

R&D firms: firms with non-zero capitalised R&D stock in a year.

R&D stock: R&D stock is capitalised past R&D expenditure following Hall et al. (2005) calculated using the perpetual inventory method: $G_{it} = (1-\delta)G_{it-1} + R\&D_{it}$. t is year, G_{it} the R&D stock in year t, $R\&D_{it}$ (adjusted to 2000 dollars) the R&D expenditure of firm i in year t, and δ the depreciation rate. The initial R&D stock equals the R&D expenses in the first year that the firm's record appears in the Compustat, divided by a depreciation rate of 15%.

R&D-to-sales: R&D expenditure/total sales (XRD/SALE).

R&D-to-assets: R&D expenditure/total assets (XRD/AT).

R&D dummy: dummy variable that equals one if R&D expenditure is positive, and zero otherwise.

Log(size): the natural logarithm of total assets adjusted to 2000 dollars by using CPI published by OECD.

Market-to-book: market value/book value of total assets ((LT+PSTKL_TXDITC+CSHO×PRCC_F)/AT).

Profitability: (earnings before interests, taxes + depreciation)/total assets (OIBDP/AT).

Tangibility: fixed assets/total assets (PPENT/AT).

Dividend payer: dummy variable that equals one if a firm pays dividends in a year, and zero otherwise.

Dividend payout: common dividend/total assets (DVC/AT).

Earnings volatility: standard deviation of profitability (OIBDP/AT) using the past ten years rolling window with at least three years of consecutive observations for the firm, and otherwise we treat it as missing (Strebulaev and Yang 2013).

Init. ZL: dummy variable that equals one if a firm's leverage in the first year recorded in Compustat is zero, and zero otherwise.

Ind.Frac.ZL: the number of zero-leverage firms in an industry (defined by Fama and French's (1997) 12-industry classification)/total number of firms in that industry.

Capital expenditure: capital expenditure/book assets (CAPX/AT).

Abnormal Cap. Ex: the growth rate of current capital expenditure compared with the average of the past three years' capital expenditure, i.e., $\frac{CE_t}{\frac{(CE_{t-1}+CE_{t-2}+CE_{t-3})}{3}} - 1$ (Titman et al., 2004).

Asset sale: asset sales/total assets ((SPPE + SIV)/AT).

Log(age): the natural logarithm of the number of years since the firm's record first appears in the Compustat plus 1.

Deciles_R&D-to-assets: categorical variable that categorizes a firm's R&D-to-asset ratio into deciles.

Deciles_R&D-to-sales: categorical variable that categorizes a firm's R&D-to-sales ratio into deciles.

Compustat HHI: we calculate a firm's market share, which is a firm's sales (SALE) over the total sales in the firm's 3-digit SIC industry in each year. Compustat HHI is then calculated as the sum of squared market shares for each industry and year (Giroud and Mueller 2010).

Price-cost margin: (total sales – cost of goods sold)/total sales ((SALE-COGS)/SALE).

Instrumented import penetration: we construct instrumented import penetration by instrumenting for the Chinese import penetration in the US (*China - US import penetration*) with Chinese import penetration in other high-income countries (*China - Developed countries penetration*), including Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland. The Chinese import penetration in the US for each 3-digit industry is calculated as the imports from China in a year and industry, divided by the sum of industry shipment plus industry imports minus industry exports in 1991 (Acemoglu et al. 2016; Lie and Yang 2023). We obtain the data from David Dorn's personal website. The data is available from 1991 to 2014.

THHI: industry concentration calculated based on the Textual Network Industry Classification. The classification is based on a textual analysis of product descriptions from

10-K filings, which is developed using the number of common words in a firm's product description. The data is available at Hoberg-Phillips Data Library. https://hobergphillips.tuck.dartmouth.edu/.

FHHI: Industry concentration calculated using Compustat data, Herfindahl data from the US Commerce Department and employee data from the Bureau of Labor Statistics. It covers both private and public firms. The data is available at Hoberg-Phillips Data Library: https://hobergphillips.tuck.dartmouth.edu/.

Log(board size): the natural logarithm of total number of board members. The data is obtained from BoardEx.

CEO tenure: number of years a CEO has served on the board. The data is obtained from BoardEx.

Independent directors: the proportion of independent directors on the board, calculated as the number of independent directors divided by the total number of board members. The data is obtained from BoardEx.

CEO gender: dummy variable that equals one if a CEO is female, and zero otherwise. The data is obtained from BoardEx.

Female directors: the proportion of female directors on the board, calculated as the number of female directors divided by the total number of board members. The data is obtained from BoardEx.

Log(compensation): the natural logarithm of total CEO compensation. The data is obtained from BoardEx.

GDP growth: the annual growth rate of gross domestic product (GDP), which is obtained from the Bureau of Economic Analysis.

Interest rate: the Federal Funds Effective Rate, which is obtained from Board of Governors of the Federal Reserve System.

Inflation: the Consumer Price Index, which is obtained from OECD.

Tariff reduction shock: We obtain tariff rate data from Frésard and Valta's personal websites. The dataset covers the manufacturing sector from 1972 to 2005. Following Frésard and Valta (2016), a tariff reduction shock in a given year is defined as a negative tariff change in a 4-digit SIC industry that is at least three times larger (in absolute value) than the industry's average change over the 1972–2005 period. We exclude events that are followed by an equivalently large increase in the tariff rate (i.e., a positive change three times larger than the average change) within the subsequent three years. We also exclude events in which the tariff rate is below 1%.

DID regression for R&D

Treat: dummy variable that equals one if a firm operates in a state that implements an R&D tax credit policy, and zero otherwise.

Post: dummy variable that equals one if a state has implemented the R&D tax credit policy by the time t, and zero otherwise.

DID regression for market competition

Treat: dummy variable that equals one if a firm operates in an industry that is affected by a tariff reduction, and zero otherwise.

Post: dummy variable that equals one if an industry has undergone a tariff reduction by the time t, and zero otherwise.

Appendix 2

Table 11 Summary statistics of variables in robustness tests

	Mean	SD	Median	*N*
	(1)	(2)	(3)	(4)
Log(board size)	2.201	0.238	2.197	29,318
CEO tenure	5.794	5.989	3.800	29,318
Independent director	0.711	0.138	0.714	29,318
CEO gender	0.029	0.167	0.000	29,318
Female director	0.092	0.099	0.091	29,318
GDP growth	0.051	0.022	0.054	92,154
Interest rate	4.738	3.872	4.970	92,154
Inflation	3.235	2.346	2.853	92,154
Price-cost margin	0.264	0.826	0.323	91,681
China-US import penetration	0.067	0.137	0.014	22,230
China-Developed countries penetration	0.052	0.094	0.010	22,230
THHI	0.321	0.285	0.207	51,187
FHHI	0.059	0.022	0.053	59,832

This table reports the summary statistics for the variables used in the robustness tests. Columns (1) to (4) report the mean, standard deviation, median, and the total number of observations for each variable

Funding The authors did not receive support from any organization for the submitted work.

Declarations

Ethical approval All the authors equally contribute to this work. No ethical approval is required for this work.

Conflict of interests The authors have no competing interests to declare that are relevant to the content of this work.

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