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This paper examines the effect of peers on a firm's R&D policy. We show that firms do not make R&D decisions in isolation, and that industry dynamics play an important role in defining a firm's R&D intensity. Using a large sample of 54,393 firm-year observations from 1991 to 2015 in the US, we find that firms' R&D decisions are mainly driven by their industry peers' R&D policies. Moreover, we find that R&D mimicking is significant only in the presence of strong product market competition, whereas we do not find any evidence of information-based herding in R&D investments. Our additional analysis shows that our main conclusions remain valid even in the presence of financial constraints, and regardless of the firms' market positions. Finally, we provide evidence that R&D mimicking increases firms' future values, future patent outputs, and estimated patent dollar values. Our findings are robust to endogeneity concerns, and to using alternative sample compositions, R&D intensity proxies, and different industry classifications.

1. Introduction

The importance of research and development (R&D) and innovation has been empirically documented in the economics and finance literature. Significant investments in R&D activities are a salient feature of a knowledge-based and innovation-driven economy (Shen & Zhang, 2013). For instance, the US invested over $500 billion annually in R&D activities during the 2017–2019 period (see Boroush, 2020). Substantial benefits to the economy, owing to knowledge diffusion and technology spillovers resulting from investments in R&D and innovation, are well acknowledged in the economics literature (Jaffe et al., 1993; Jiang et al., 2016; Romer, 1986). R&D investments, technological advances, and knowledge spillovers have been the central determinants of long-term economic growth (Liu, 2016; Romer, 1986). At the firm level, R&D and innovation are found to be strongly associated with firm performance (Eberhart et al., 2004; Griliches, 1979; Sougiannis, 1994). While most of the studies mentioned above focus on how a firm's R&D affects its accounting and stock performance, we focus on how firms respond to the R&D investments of their rivals and industry peers.

Competitive rivalry theory suggests that firms may respond aggressively to their peers' R&D investments to preserve their competitiveness within their industries (Lieberman & Asaba, 2006). For instance, they may react by increasing their R&D investments compared to their peers. In this vein, Apple's 2020 10-K (p. 23) highlights that "*The Company continues to believe that focused investments in R&D are critical to its future growth and competitive position in the marketplace, and to the development of new and updated products and services that are central to the company's core business strategy.*" On the other hand, firms may not react if they do not perceive their competitors' R&D investments as a threat to their own profitability.

Due to the idiosyncratic nature of R&D decisions, it is not easy for external stakeholders to fully understand the motivation behind R&D investments made by peer firms (Wyatt, 2005). As a result, information asymmetry around R&D investments can have conflicting consequences for peers. On one hand, in the presence of information asymmetry, managers may imitate the R&D behavior of their peer firms to avoid losing competitiveness (Banerjee, 1992). On the other hand, the expensive and irreversible nature of R&D investment decisions may discourage managers from doing so. One of the objectives of this paper is to deepen our understanding of R&D and industry dynamics and explore their importance as a key determinant of firms' R&D investment decisions (Gu, 2016; Kamien et al., 1992; Machokoto et al., 2021; Suzumura, 1992).

We use a large sample of 54,393 observations of US-listed firms over the period of 1991-2015 to investigate whether industry dynamics drive firms' R&D decisions. The choice of US firms is motivated by their high business enterprise R&D expenditures[1] and patent applications[2]. Our findings reveal that US firms take into account the R&D intensity of their competitors when making decisions about their own R&D policies. These results are robust to different regression specifications and estimation techniques, alternate proxies for R&D intensity, and alternative peer and sample compositions.

One potential problem in our estimations is endogeneity, which is one of the major challenges in the current corporate finance literature, particularly in studies related to peer effects, where the reflection problem is most prevalent (Manski, 1993). We provide two possible approaches to address this issue. First, we check our primary model for omitted-variable bias using additional control variables. The outcomes indicate that our primary evidence remains consistent with our initial findings. Additionally, we conduct a two-stage least squares (2SLS) regression analysis with

[1] https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS
[2] https://data.worldbank.org/indicator/IP.PAT.RESD

instrumental variables to alleviate concerns regarding potential simultaneity bias and reverse causality. Our results alleviate any doubts arising from endogeneity, thereby validating our primary empirical findings.

Furthermore, we find that the peer effect of R&D intensity is only significant in the presence of intense competition. In our additional analysis, we determine that financial constraints and cross-sectional heterogeneity in firms do not drive our results for R&D mimicry. Lastly, we provide evidence that R&D mimicry is value-enhancing for a firm and positively affects the number and estimated dollar value of its patents.

This paper contributes to prior literature in two ways. Firstly, it expands our understanding of the factors that determine firms' R&D investment by exploring a relatively new area of research in finance. It goes beyond the conventional firm-level factors that affect such decisions and examines the impact of peers' R&D choices on firms' R&D policies. This is an essential contribution since most earlier researchers have focused mainly on firm-level determinants of R&D investments. Following peers in R&D is a costly and irreversible investment decision, which is subject to information asymmetry, takes time, and requires sunk costs (see, e.g., Czarnitzki & Toole, 2011, 2013; Ghosal & Loungani, 2000). Therefore, it is important to understand how industry dynamics affect R&D decisions. Only a few papers have explored the external factors affecting the R&D strategies of firms. For example, Cowan & Cowan (1998) have found that R&D activities in the US are geographically clustered because of local positive externalities. In addition, few papers have examined the impact of research joint ventures, R&D cartels, cooperative and noncooperative R&D, and innovation spillovers under various competition conditions. We provide evidence that R&D mimicry can benefit firms in a competitive world, as it likely results in increased patents and positively impacts firm value.

Secondly, our contribution to the information- and rivalry-based explanations of peer effects adds to the recent research examining various types of peer effects on firms' corporate policies. Li et al. (2014) provide support for the rivalry-based channel by proposing that firms' tax avoidance depends on the existence of similar policies among their competitors. Seo (2021) also highlights this channel of rivalry by finding that a higher intensity of strategic interaction (competition) forces firms to disclose more information if their rivals are doing so. Consistent with the rival-based theory, Gyimah et al. (2020) find that firms' trade credit policy depends on whether their product market peers have similar policies. The information-based channel is explained by Matsumoto et al. (2017) in their work on geographic peer effects on management earnings forecasts. They argue that managers' decisions to issue earnings forecasts depend on similar choices made by nearby firms, as geographic proximity facilitates information sharing through local interaction. Wang (2015) argues that in the information environment, disclosures by peer firms may increase investors' reservations regarding non-disclosing firms, thus forcing them to disclose more. Our contribution to this strand of research is examining the peer effect on firms' R&D investment decisions and providing evidence that rivalry-based mimicking plays a role in firms' R&D policies.

Furthermore, our study contributes to the rapidly growing field of behavioral corporate finance, specifically in the area of peer effects in corporate financial policies, by examining the influence of peers on firms' R&D decisions. Recent literature has provided empirical evidence of peer effects in firms' financial policies and stock market activities. For instance, Chen et al. (2019) find that the average cash holdings of peer firms significantly affect a firm's cash-holding decisions. Similarly, Leary and Roberts (2014) demonstrate that a firm's capital structure is positively related to the similar choices of its industry peers. Bustamante and Frésard (2021) and Park et al. (2017) identify similar peer effects in firms' investment decisions. Grennan (2019) discovers that top executives follow their industry peers in setting dividend targets, and suggests that these peer effects can be explained through knowledge about peers' dividend policy, industrial strategy with related predatory behavior, executive overconfidence, and executive reputation-building measures.

The paper is structured as follows: Section 2 reviews the relevant literature on R&D and peer effects, and develops our hypotheses. Section 3 outlines our sample and variable definitions and provides descriptive statistics. Section 4 presents our main results and robustness checks, addressing endogeneity concerns. Section 5 provides additional tests. Finally, the last section summarizes our findings and concludes the paper.

2. Literature review and hypothesis development

2.1. R&D and peer effects

Griliches (1979), in his knowledge capital model, argues that firms' R&D activities enhance their accumulated knowledge, and increase their productivity by improving quality and reducing costs. Prior research has shown that R&D expenditures reflect the state of a firm's technical knowledge and increase its performance (Doraszelski & Jaumandreu, 2013). Bøler et al. (2015) investigate the combined effect of R&D investments and imported inputs on firm performance after a reduction in R&D costs, finding significant returns for firms with foreign sourcing. Sougiannis (1994) and Zhao (2002) show that R&D investments have a significant effect on a firm's accounting earnings and relative value relevance. Sougiannis (1994) finds that, on average, a one-dollar increase in R&D investments over a seven-year period translates into a two-dollar increase in the firm's profits and a five-dollar increase in its market value. Simeth & Cincera (2016) discover that scientific publications and R&D investments positively influence a firm's market value. Chan et al. (2001) and Eberhart et al. (2004) find a strong positive association between firms' R&D expenses and stock returns.

Given the positive effect of a firm's R&D activities on its future performance and the general impact of R&D-led innovation on economic growth, it is vital to examine the factors that influence a firm's R&D activities. Previous studies have identified various financial and institutional variables associated with a firm's R&D and innovation. For example, extensive research has provided evidence of a strong relationship between firms' R&D investments and cash holdings (Brown & Petersen, 2011), book-to-market (Lev & Sougiannis, 1999), financial constraints (Brown et al., 2012; Li, 2011), distress risk (Franzen et al., 2007), firm size (Cohen et al., 1987; Ja, 1942; Pavitt et al., 1987), debt (Bah & Dumontier, 2001), institutional ownership (Bushee, 1998), and analyst coverage (He & Tian, 2013), among other attributes.

It is increasingly evident from a growing body of literature that firms do not operate in isolation, and their corporate policies may result from strategic interactions as they constantly monitor their peers and industry rivals to maintain their competitive edge in the market. For example, there is evidence of the presence of peer effects in firms' corporate social responsibility (Cao et al., 2019; Husted et al., 2015; Jiraporn et al., 2014), board compensation (Liu et al., 2009), disclosure decisions (Seo, 2021), earnings forecast decisions (Wang, 2015), financial reporting (Gleason et al., 2008; Beatty et al., 2013; Li, 2016), individual investment decisions (Ouimet & Tate, 2020), mergers and acquisitions (Wu et al., 2020), risk aversion and trust (Ahern et al., 2014), tax avoidance (Li et al., 2014), tax planning (Bird et al., 2018), and CEO compensation (Albuquerque et al., 2013; Bizjak et al., 2008).

Given the above-mentioned arguments and the importance of R&D investments in firms' performance and competitiveness, it is reasonable to expect that peer effects also play an important role in firms' R&D decisions. Therefore, we propose the following hypothesis:

H1: A firm's R&D intensity is positively associated with that of its industry peers.

2.2. R&D intensity, information asymmetry, and competition

In an attempt to answer the question of why firms imitate each other, Lieberman and Asaba (2006) identified two broad categories of business imitation theories. According to information-based theories, managers tend to imitate the decisions of their peer firms if they perceive that the latter has superior information about the outcomes of these decisions. The rivalry-based theories, however, argue that firms imitate their peers' decisions as a part of their competitive process to preserve their competitiveness within their industries. These theories can help in understanding the peer effect's role in firms' R&D decisions.

Firms currently face strong competition both within and outside their industry. One way to gain a competitive advantage over competitors is to develop new products and processes through investment in R&D activities. For example, Sutton (1991) finds that firms invest in R&D to differentiate themselves from rivals and gain a competitive advantage by creating barriers to market entry. Similarly, Hoberg & Phillips (2016) find that US firms conduct R&D to differentiate their products from those of competitors, which may force competitors to invest more in R&D to match the quality of their peers in order to avoid losing market share and customers. This investment spiral generates spillover effects, in which competing firms follow each other into R&D investment decisions. For instance, when firms develop a new product through R&D, they gain a competitive advantage, which helps increase their market share. A competing firm in the industry may view this as a threat to its own market share, leading to a likely decline in its stock price. To regain its competitive position and market share, the firm may increase its investment in R&D to develop a similar or new product that re-equalizes its competitiveness in the market or provides a competitive advantage over its rival. The existing literature also shows evidence of peer mimicking to address competitive threats in financial policies. For example, Rind et al. (2021) find that firms' trade credit policies are influenced by the trade credit decisions of their peers, as fierce competition forces firms to offer trade credit when peers are providing such facilities. Therefore, rivalry is considered a potential channel through which R&D peer effects operate. Based on this conjecture, we propose the following hypothesis:

H2: The relationship between a firm's R&D intensity and that of its industry peers is more pronounced in the presence of strong rivalry.

It is natural to assume that there exists information asymmetry regarding a firm's decisions between insiders and outsiders. Aboody & Lev (2000) show that this information asymmetry is even more crucial when it comes to R&D investments. Considering the idiosyncratic nature of R&D investments, it is difficult for external parties to infer a firm's future R&D value based on the performance and products of its peers. Empirical evidence supports this view. Tasker (1998) argues that inferring information about R&D activities through traditional financial reporting channels is particularly challenging. Barth et al. (2001) conclude that analyst following is higher for R&D-intensive firms in the US than for other firms, likely due to the information-asymmetric nature of R&D activities. Aboody & Lev (2000) also argue that the accounting rules and the absence of organized markets for R&D make it particularly challenging to infer the value and productivity of a firm's R&D.

The presence of information asymmetry in R&D investments may result in two contrasting views. First, less informed managers may mimic the policies of their informed counterparts in a herd-like fashion. For example, Banerjee (1992) observes that people tend to follow others rather than relying on their own information because they believe that others are better informed. Ellison & Fudenberg (1995) argue that economic agents rely on information obtained through social interaction to make decisions. Recent literature on peer influence provides some evidence of information-based mimicking in firms' financial policies. For instance, Matsumoto et al. (2017) provide evidence of mimicking in earnings management in the US context. Wang (2015) shows that a firm is more likely to provide additional disclosures if peers do so, and Gyimah (2020) shows the occurrence of this herding in trade credit policies. The evidence on the information environment and mimicking behavior suggests that due to the presence of information asymmetry in R&D activities, firms may imitate others in R&D investments, and this imitation is more likely to occur in firms facing higher uncertainty. Second, it is also possible that the considerable cost and uncertainty associated with R&D investments may discourage managers from following peers in R&D investments (Czarnitzki & Toole, 2011, 2013; Ghosal & Loungani, 2000). This could result in no or a negative relationship between firms' and peers' R&D investments. Therefore, we propose the following hypothesis.

H3: The relationship between a firm's R&D intensity and that of its industry peers becomes more pronounced in the presence of high information asymmetry.

3. Data and descriptive statistics

3.1. Sample and variable definitions

We obtain accounting and financial data for all US listed firms from 1991 to 2015 from Compustat. Information on institutional ownership and analyst coverage are gathered from the Thompson and I/B/E/S databases, respectively. After merging these databases and removing observations with missing data, we are left with a final sample of 54,393 firm-year observations. Our sample covers all industries, including the financial and utility sectors. Later in the paper, we will demonstrate that our results are robust to eliminating firms from these two sectors. To remove the effect of outliers, we winsorize all continuous variables at the first and 99th percentiles.

To measure R&D intensity, we followed Franzen et al. (2007) and He & Tian (2013) among others, and used the ratio of R&D expenditure to total assets (variable R&D Intensity). The US Securities and Exchange Commission does not require firms to report R&D expenses if they represent less than 10% of sales, general and administrative (SG&A) expenses, or less than 1% of sales. Furthermore, firms are not obligated to report R&D expenses if they are immaterial or if a firm chooses to amortize or defer R&D expenses. Given this, and following the standard practice in the literature (e.g., Koh & Reeb, 2015; Lewis & Tan, 2016), we replace missing R&D expenditure observations with zero.

Following the industry classification of Fama and French (1997), we define peers as firms operating in the same industry, as done in prior studies such as Choi & Sias (2009) and Dougal et al. (2015). Our main independent variable, Peer R&D Intensity, is computed for each sample firm as the average R&D Intensity of all its peers. Additionally, we control for various firm characteristics, including *Size* (the natural logarithm of total assets), *Tobin's Q* (the market-to-book ratio of a firm during fiscal year t, calculated as the sum of its market value of equity and book value of assets, minus the book value of equity and balance sheet deferred taxes [set to zero if missing], divided by the book value of assets), *Tangibility* (fixed assets divided by total assets), *Leverage* (total debt divided by total assets), *Capex* (capital expenditure divided by total assets), *Institutional Ownership* (the percentage of institutional ownership in a firm), and *Analyst Coverage* (the number of analysts providing earnings estimates for the next year). Appendix A displays variable definitions and data sources.

3.2. Empirical model

Following Leary & Roberts (2014), we use the following model to measure peer effects on firms' R&D intensity:

$$y_{i,j,t} = \alpha + \beta\bar{y}_{-i,j,t} + \acute{\lambda}X_{i,j,t-1} + \acute{\gamma}\bar{X}_{-i,j,t} + \acute{\delta}\mu_j + \varphi\nu_t + \epsilon_{i,j,t} \quad (1)$$

where the subscripts i,j, and t refer to firm, industry, and year, respectively; the dependent variable $y_{i,j,t}$ is *R&D Intensity*; $\bar{y}_{i,j,t}$ is the average *R&D Intensity* of the firm i's industry peers; $X_{i,j,t-1}$ is a set of lagged control variables, namely *Size*, *Tobin's Q*, *Tangibility*, *Leverage*, *Capex*, *Institutional Ownership* and *Analyst coverage*; $\bar{X}_{i,j,t}$ is a set of control variables' averages of all the peers of firm i; μ_j and ν_t refer to industry- and year-fixed effects; and $\epsilon_{i,j,t}$ is the firm-year-specific error term. The coefficient of interest is β, which explains the peer effects on firm i's R&D investments.

3.3. Descriptive statistics

Table 1 provides the distribution of our sample observations by industry, based on the Fama and French classification, and by year. The sample includes 54,393 firm-year observations covering 7,958 unique US listed firms. The computer software industry accounts for 10% of the sample observations, followed by the electronic equipment and pharmaceutical products industries with 7.11% and 7%, respectively. On average, a sample firm has 97 peer firms annually, with the median number of peer firms being 78, based on the Fama and French 49 industry classification. Table 2 displays descriptive statistics for the variables used in our analysis. The table shows that the mean (median) R&D Intensity of our sample firms is 0.054 (0.003), which is similar to prior studies such as Franzen et al. (2007) and He and Tian (2013). The summary statistics for the control variables are also similar to those reported in earlier studies.

[Insert Table 1 about here]

[Insert Table 2 about here]

Table 3 presents the Pearson correlation matrix for all variables. Our primary dependent variable shows a significant correlation with our variable of interest and all control variables. However, some control variables exhibit high correlation coefficients with each other. Nonetheless, none of the correlation coefficients exceeds 0.8, indicating that multicollinearity is unlikely to affect our findings. Moreover, we calculate the variance inflation factor (VIF) for our primary regression model to check for potential multicollinearity. We find that the VIF for all control variables is below 4, further supporting the absence of multicollinearity in our data.

[Insert Table 3 about here]

4. Main evidence

4.1. Peer effects in R&D

To investigate the peer effects in R&D, we conduct pooled ordinary least squares (OLS) regressions with standard errors adjusted for clustering by firm. Table 4 presents the regression results. In Column (1) we regress *R&D Intensity* against *Peer R&D Intensity* and *Size*. The results indicate that both variables are significantly related to the R&D intensity of the firm at the 1% level. The coefficient on *Peer R&D Intensity* is positive, suggesting that firms' R&D intensity increases with the level of their peers' R&D activity, thus supporting hypothesis H1. The coefficient for Size is significantly negative, indicating that smaller firms tend to invest more of their resources in R&D than larger firms do. This finding is consistent with previous studies, such as Coles et al. (2006) and Hirshleifer et al. (2012), and can be explained by larger firms' tendency to take fewer risks.

Column (2) presents the results of regressing *R&D Intensity* against *Peer R&D Intensity* and the complete set of control variables. The coefficients for *Peer R&D Intensity* and *Size* are qualitatively similar to those reported in Column (1). This effect is also economically meaningful, as a one standard deviation increase in peers' R&D intensity leads to a 3.5 percentage points increase in the R&D intensity of sample firms, *ceteris paribus*. Additionally, *Tobin's Q* has a positive coefficient that is significant at the 1% level, indicating that firms that perform better spend more on R&D, consistent with Koh and Reeb (2015) and He and Tian (2013). The coefficient on *Leverage* is also positive and statistically significant, indicating that firms with higher leverage invest more in R&D activities. Prior research suggests that R&D investment is negatively associated with leverage, as more debt payments mean less cash available for R&D investments (Hall, 1992; Desyllas & Hughes, 2010). However, from a strategic standpoint, managers and lenders may be incentivized to provide a company with funds to invest in R&D activities to maintain its competitive position in its industry, which explains the positive relationship between *Leverage* and *R&D Intensity*. The coefficients for *Tangibility*, *Capex*, and *Institutional Ownership* are negative and statistically significant, suggesting that investment in fixed assets and capital expenditure are substitutes for R&D investments, while a high level of institutional ownership may lead to myopic investment behavior by reducing investments in R&D (Bushee, 1998; He & Tian, 2013; Hillier et al., 2011). Furthermore, the coefficient for *Analyst Coverage* is significantly positive at the 1% level, indicating that companies with higher R&D investments are covered by more analysts, supporting the notion that R&D significantly contributes to information asymmetry (Aboody & Lev, 2000; Barth et al., 2001).

To account for possible autocorrelation and heteroscedasticity, we re-estimate our model using the weighted least squares method, where the weights are based on the annual number of observations. The results, presented in Column (3), remain qualitatively unchanged, providing further support for hypothesis H1.

[Insert Table 4 about here]

4.2. Sensitivity tests

4.2.1. Alternate Proxies for R&D

We conduct tests to check the robustness of our results using alternative measures of R&D intensity. In Column (1) of Table 5, we rerun our baseline regression using the ratio of R&D to total sales instead of R&D scaled by total assets to construct the variables *R&D Intensity* and *Peer R&D Intensity*, following Chung et al. (2003) and Cui & Mak (2002). We find that the results remain qualitatively unchanged. Furthermore, we used *R&D per employee*, *R&D to capital expenditure*, and *R&D to operating expenses* as alternative proxies for R&D intensity, following previous studies such as Amore et al. (2013), Brown & Krull (2008), Croce et al. (2019), Hill & Snell (1989), Kochhar & David (1996), and Xiao (2013). The results, presented in columns (2), (3), and (4) of Table 5, respectively, are also qualitatively similar to those of Table 4, with all the coefficients of *Peer R&D Intensity* being significantly positive at the 1% level.

[Insert Table 5 about here]

4.2.2. Alternative sample compositions, peer proxies, and estimation techniques

We examine the sensitivity of our main results to different sample compositions. First, replacing missing R&D values with zeros may create a selection bias towards small firms with low R&D activity (Denis, 1994; Kumar & Li, 2013). To address this issue, we rerun our main regressions after dropping all firm-year observations with zero R&D intensity. The results are presented in Column (1) of Table 6. The regression results suggest that dropping zero R&D intensity observations does not affect our main conclusions.

Next, we examine the robustness of our results by testing alternative proxies for peer R&D intensity. First, we define peers based on the text-based network industry classification (TNIC) proposed by Hoberg and Phillips (2016). In other words, we identify peer firms as those with similar product descriptions in their 10-K filings, which has been shown in the literature to be highly relevant (e.g., Cao et al., 2019). Furthermore, this approach is more direct, dynamic, and robust than the Fama-French or the SIC code-based classifications since peers for a typical firm change according to the changes in its product descriptions (Hoberg & Phillips, 2016). We use the TNIC-based measure of peer R&D intensity to re-estimate our main pooled OLS regression in Column (2) of Table 6. The coefficients of our main independent variable and all control variables are virtually the same as in the main regression of Table 4.

Second, we follow Leary and Roberts (2014) and measure peer firms' R&D intensity for each firm *i* as the average R&D intensity of all other firms in the same industry and year. We present the results in Column (3) of Table 6, where peers are based on a 3-digit SIC code. We find qualitatively similar results to those shown in Table 4.

Third, in Column (4) of Table 6, we replace the variable Peer R&D Intensity used in Table 4 with another proxy that uses the peers' median R&D intensity instead of the average. Regardless of whether we use the median or the mean to compose peer groups, our results remain qualitatively the same, indicating that data skewness and outliers do not drive our results.

Next, we investigate whether the degree of R&D intensity within industries influences our main results. High-tech industries are known to invest more heavily in R&D than other industries, which may affect our results. To address this concern, we split our sample into high-tech and non-high-tech firms based on Fama and French's (1997) classification. We select nine high-tech industries, including business services, computers, computer software, electrical equipment, electronic equipment, measuring and control equipment, medical equipment, pharmaceutical products, and telecommunications. All other firms are included in the non-high-tech sample. Columns (5) and (6) of Table 6 report the results for both subsamples. As expected, the coefficient of *Peer R&D Intensity* is statistically significant at the 1% level for high-tech firms and significant at the 10% level for non-high-tech firms, suggesting that peer following is stronger among high-tech firms than their non-high-tech counterparts.

Lastly, since many firms have changed their investment behavior during the recent financial crises and because the presence of financial firms and regulated utilities creates heterogeneity of extraneous factors across industries, we address the issue of whether periods of financial crises or the presence of financial utilities in our sample can influence our results (DeAngelo et al., 2004; Denis & Osobov, 2008). To account for these factors, we exclude financial firms, regulated utilities, and the crisis periods of 2008 and 2009. Column (7) of Table 6 shows the regression results, which remain significantly positive at the 1% significance level between firms' R&D intensity and their peers' R&D intensity. Overall, our results are robust to different sample compositions, further corroborating our main findings in Table 4.

[Insert Table 6 about here]

4.2.3. Addressing endogeneity

One main concern regarding our analysis is the potential for endogeneity resulting from measurement errors, omitted variable bias, reverse causality, or simultaneous determination of the R&D intensity of the firm and its peers. Our results are robust to alternative proxies for R&D intensity (see Table 5), indicating that our findings are unlikely to be driven by measurement errors. To address the problem of omitted variable bias, we introduced several additional control variables that could potentially affect our findings. The results are presented in Table 7. First, following Brown et al. (2012), we rerun our primary regression after including *Cash Holdings*, defined as the ratio of cash to total assets, and present the results in Column (1) of Table 7. We continue to find that *Peer R&D Intensity* is significantly positive at the 1% level. Additionally, consistent with previous research (e.g., Brown & Petersen, 2011), we find that a firms' cash holdings are positively related to their R&D

intensity. In Column (2), we replace the variable *Cash Holdings* with *Market to Book*, defined as the ratio of the market value of assets to book value of assets (Griliches, 1981). As expected, our main results remain qualitatively the same as those of Table 4, and the relationship between firms' market to book ratio and their R&D intensity is positive and statistically significant, which is in line with prior studies such as Chauvin & Hirschey (1993) and Hall et al. (2005). We also use the variable *Distress Risk* as an additional control, defined as Altman (1968)'s Z-score. Since the Z-score does not apply to the financial and utility industries, we drop them from our sample when using this variable. The regression results are presented in Column (3) of Table 7. We find that the regression coefficients for the independent and control variables are qualitatively similar to those of Table 4. Furthermore, the coefficient for *Distress Risk* is significantly negative at the 1% level, suggesting that firms with higher financial distress risk spend less on R&D activities, which is consistent with the findigs of Li (2011).

Furthermore, Dougal et al. (2015) find that a company's geographic location plays a crucial role in determining its investment behavior. Specifically, the authors show that a firms' investment expenditures are sensitive to those of other firms headquartered in the same geographic area. This finding implies that some local effects, which have not been accounted for, may influence our main conclusions. To address this issue, we created an additional variable for the location of a firm's headquarter. We use each company's metropolitan statistical area (MSA) where its headquarter is located and calculate its *MSA R&D Intensity*, defined as the average R&D intensity of other firms headquartered in the same MSA. We then rerun our main regression after adding *MSA R&D Intensity* as an additional control variable. The results are presented in Column (4) of Table 7. We find that the coefficient of *MSA R&D Intensity* is positive and statistically significant at the 1% level, indicating that a company's R&D intensity is influenced by other companies in its vicinity. Interestingly, our main variable of interest, *Peer R&D Intensity*, remains statistically significant at the 1% level, providing further support for hypothesis H1. Finally, Column (5) displays the regression results after including all the additional controls mentioned above in one pooled OLS specification. We find similar results to those in Columns (1)-(4) of Table 7, further alleviating concerns that omitted variables may bias our main findings.

[Insert Table 7 about here]

Another robustness test that can help mitigate omitted-variable bias is to run a fixed effects regression. This approach controls for time-invariant firm-specific unobservable characteristics that may influence our main conclusions. We also consider three proxies for R&D intensity, namely R&D to total assets, R&D to total sales, and R&D to the number of employees. We present the results in columns (1) to (3) of Table 8. The results show that peers' R&D intensity is positively and significantly associated with R&D intensity. To ensure that endogeneity does not bias our findings, we employ a 2SLS instrumental variable model (Columns (4) to (6) of Table 8) and a dynamic GMM approach (Columns (7) to (9) of Table 8). Following Leary and Roberts (2014), we use peer firms' average idiosyncratic stock returns as an instrumental variable to proxy for average peer R&D intensity. We estimate *idiosyncratic stock returns* using the three-factor model proposed by Fama and French (1997). Interestingly, one would expect this instrument to be correlated with peer firms' risky investments in R&D, but it is unlikely that the change in R&D intensity of one firm affects the average idiosyncratic component of stock returns of the entire industry. Columns (4) to (6) of Table 8 indicate that our instrumental variable is positively associated with the average peer R&D intensity in the first-stage regression. An F-test of the excluded variables rejects the hypothesis that our instrument is weak. Additionally, like El Ghoul and Zheng (2016), we use the Sanderson-Windmeijer (SW) test to conduct an underidentification test. Based on an SW first-stage chi-square test, we reject the null hypothesis that our endogenous regressor is unidentified. The second-stage regression results indicate that the coefficient of our main independent variables is significantly positive at the 1% level, further supporting our main findings.

Last but not least, we perform a two-step system GMM approach using peer average *idiosyncratic stock returns* as an instrument (Blundell & Bond, 1998). Consistent with our previous results, we find that the coefficients of our peer R&D intensity proxies are positive and statistically significant in all three specifications in columns (7) to (9). We employ three tests to assess the efficiency and consistency of the GMM estimator. First, we test the instrument's validity through *Hansen's J test* of overidentification restrictions. The null hypothesis under *Hansen's J test* is that the instrument is exogenous, in keeping with the assumption that it is uncorrelated with the error term. Since the *Hansen's J test* values (p-values) in all specifications from columns (4) to (6) are greater than 0.1, we accept the null hypothesis, validating the exogeneity of our instrument. Second, AR(1) rejects the null of no autocorrelation in the first-differenced residual. Last, under AR(2), the null implies that there is no second-order serial correlation and that the residuals in the level equation are not serially correlated, which is accepted as the p-value is greater than 0.1 for AR(2). The results suggest that serial correlation is not a problem in our analysis. The above results validate the consistency and efficiency of our GMM estimator. The results also confirm our earlier findings that firms do not make R&D decisions in isolation and that the R&D intensity of their peer firms has a significant and positive impact on their own R&D intensity.

[Insert Table 8 about here]

5. Why do firms follow their peers in R&D intensity?

5.1. Product market competition and peer effects in R&D intensity

In this section, we focus on the first potential channel through which peers can influence firm R&D intensity. Specifically, we examine whether competition plays a role in R&D peer effects. We argue that competition is associated with several firm decisions, including R&D investments, as it creates an environment for firms to imitate each other (e.g., Seo, 2021). Therefore, it is reasonable to expect that product market competition plays an important role in explaining peer effects in R&D intensity. To empirically explore this channel, we divide our sample into firms operating in high and low competitive industries based on the median values of three product market competition proxies. We then re-estimate our main regression from Table 4 on each resulting sub-sample. The regression results are displayed in Table 9. We consider three product market competition proxies: the TNIC-based Herfindahl–Hirschman index (TNIC HHI, columns (1) and (2)), product-market similarity (columns (3) and (4)), and product-market fluidity (columns (5) and (6)). TNIC HHI is a market concentration measure calculated as the sum of the squared market shares using firm sales, wherein industry is based on the TNIC industry classification of Hoberg and Phillips (2016). The product market similarity index measures the similarity between a firm's product descriptions and those of industry peers using the TNIC industry classification. While fluidity measures the Cosine similarity between a firm's own words vector and the change in rivals' words vector. Using all three proxies for competition, we find that the coefficients of *Peer R&D Intensity* are significantly positive only in columns (1), (3), and (5) of Table 9, implying that firms follow their peers in R&D intensity only in highly competitive industries, characterized by low TNIC HHI, high product-market similarity, and high market fluidity. Overall, these results indicate that the competitive nature of the industry in which a firm operates influences its tendency to follow its peers in R&D intensity, which supports the competition channel.

[Insert Table 9 about here]

5.2. Information asymmetry and peer effects in R&D intensity

In this section, we explore the role of information asymmetry in R&D peer effects. Previous studies have typically considered R&D investments as a source of information asymmetry (Aboody & Lev, 2000; Barth et al., 2001; Tasker, 1998). When a firm's peers change the levels of their R&D intensity, its managers may perceive that their peers are better informed about new technological changes and consequently decide to follow them in R&D investments, resulting in stronger peer effects in R&D intensity (e.g., Banerjee, 1992; Ellison & Fudenberg, 1995; Matsumoto et al., 2017; Wang, 2015). Thus, information asymmetry may contribute to R&D peer effects, and we expect less informed firms to follow their more informed counterparts in terms of R&D intensity.

To investigate the information asymmetry channel, we divide our main sample into high- and low-information asymmetry firms based on two proxies for firms' information environment: analyst coverage and bid-ask spread. We obtain data on analyst coverage and pricing information from the Institutional Brokers Estimate System (IBES). We present the results in Table 10. We first proxy analyst coverage by the number of analysts providing one-year-ahead earnings per share (EPS) estimates for the firm. Firms are considered to have high (low) information asymmetry if the number of analysts covering a firm is less than or equal to (greater than) the industry-year median. Specifications in columns (1) to (4) report baseline regression results for the two subsamples. We find that regardless of the magnitude of information asymmetry, R&D peer effects are significant, and both high- and low-information asymmetric firms follow their peers in R&D intensity. To test the robustness of our results, we use bid-ask spread as an additional measure of information asymmetry. Following Chen et al. (2015), we calculate the monthly average bid-ask spreads as

0.5*(AskBid)/(Ask+Bid), quoted during normal trading time, and then take the annual average of the monthly bid-ask to form our bid-ask spread measure. We divide firms into high- and low-information asymmetric groups based on whether the annual bid-ask value is higher or lower (or equal to) than the median. Specifications in columns (5) to (8) report the results of these two subsamples, where we use our main baseline regression model as in Equation (1). Once again, our results remain robust, and we find no sufficient evidence supporting the role of information asymmetry in motivating firms to imitate others in R&D decisions.

[Insert Table 10 about here]

6. Additional analysis

6.1. Cross-sectional heterogeneity

In this section, we aim to test for cross-sectional heterogeneity in R&D peer effects. Specifically, we investigate whether firms' financial constraints and market position have an impact on their decision to emulate others in terms of R&D intensity. The objective is to delve deeper into the mechanisms that underlie R&D peer effects.

6.1.1. R&D peer effects and financial constraints

To begin with, we will examine whether peer-following in R&D varies between unconstrained and constrained firms. Financial constraints are a significant determinant of a firm's R&D investment (Borisova and Brown, 2011). The literature provides two contrasting views on the relationship between financial constraints and R&D. Firstly, studies that examine R&D and financial constraints show that access to finance is one of the essential factors in determining a firm's R&D investments (Brown et al., 2012; Guariglia & Liu, 2014; Li, 2011). One may argue that it is easier for unconstrained firms to access external finance; hence, they may have the resources to finance R&D investments compared to constrained firms. R&D is a challenging task, and the unavailability of the necessary funds can seriously affect a firm's decision to invest in R&D because of limited or no collateral, huge adjustment costs, cash-flow uncertainty, and potential information asymmetry of the projects (Brown & Petersen, 2011; Hall and Lerner, 2010). Earlier studies show a strong positive association between R&D and cash flow and equity finance in US firms (Brown, Fazzari, and Petersen, 2009; Brown and Petersen, 2009; Himmelberg and Petersen, 1994). Brown and Petersen (2015) argue that firms facing financial constraints reduce R&D investments much more aggressively than they reduce other capital investments. Hence, firms with easy access to finance may be more likely to follow others in R&D investments compared to firms with financial constraints. Additionally, Pham et al. (2018) show that firms with highly liquid assets invest more in R&D activities and perform more innovation, as reflected in higher numbers of patents and patent citations.

Alternatively, financial constraints may not be a significant factor in R&D investments as it differs significantly from other capital expenditures. Due to R&D's purpose of knowledge creation, its impact on firms' future profits is relatively higher than that of investments in other capital projects. As firms that invest in R&D earn higher returns in the long run compared to firms that do not make such an investment (Hou, Xue, & Zhang, 2015), we argue that higher expected future returns may motivate constrained firms to invest more in R&D activities. Furthermore, managers in firms with reputational concerns and financial constraints have strong incentives to follow peers to improve their future employment prospects (Scharfstein & Stein, 1990). In line with the argument posed by Hirshleifer and Teoh (2003), we assume that even constrained managers try to mimic the behavior of other agents to maximize the market perception of their personal ability. Additionally, the literature on reputational concerns argues that financially constrained firms try to develop their reputation in the market. One way of creating goodwill and a reputation is cutting-edge innovation, which can be achieved through R&D investments. Hence, these firms have incentives to invest in R&D activities compared to firms that are not financially constrained.

To examine these contrasting views, we employ four constraint measures from the literature and divide firms into unconstrained and constrained firms based on the annual median values of their respective constraint indices. Values lower than the median represent non-constrained firms, and vice versa. Next, we run our baseline regression model on all subsamples of non-constrained and constrained firms, as shown in Table 11. Specifically, in columns (1) and (2), we divide firms into unconstrained and constrained firms based on the Kaplan and Zingales index (1997) (hereafter, the KZ index). In columns (3) and (4), we use the WW index proposed by Whited and Wu (2006). In columns (5) and (6), we replace the WW index with the SA index developed by Hadlock and Pierce (2010), and in columns (7) and (8), we use the newly developed text-based constraint index proposed by Hoberg and Maksimovic (2015). In all our specifications in Table 11, we find that both unconstrained and constrained firms invest in R&D intensity based on peers' investment. However, the magnitude of mimicking is higher for constrained firms, supporting the view relating to the profitable nature of R&D investments and firms' reputational concerns. Nevertheless, we do not rule out the other view relating to access to finance and external funds, as we also find significant mimicking behavior in non-constrained firms.

[Insert Table 11 about here]

6.1.2. R&D peer effects and firms' market position

We now shift our focus to the impact of firms' market position on their ability to emulate peers in R&D intensity. To investigate whether market position affects firms' decision to follow others in R&D investment, we use three proxies to measure firms' market position. First, we divide firms into leaders and followers based on the industry's annual median values of their market capitalization.

Firms with higher market capitalization than the median are classified as leaders, and those with lower market capitalization as followers. Additionally, we use firm's growth opportunities, based on Tobin's Q, and firm age as proxies for leaders and followers, where higher than median values of Tobin's Q and firm's age represent high-growth and old firms, and lower than median values represent low-growth and young firms. After categorizing the firms, we run our primary empirical model on these subgroups and report the findings in Table 12.

In columns (1) and (2), we examine whether low-market capitalization firms respond to the R&D policies of their low and high-market capitalization peers, while in columns (3) and (4) we investigate whether high-market capitalization firms react to the similar policies of their high and low market capitalization peers. The results indicate that both low- and high-market capitalization firms are influenced by peer policies in all subgroups. However, the magnitude of peer influence is stronger among similar peer groups (low-low and high-high) compared to low-cap firms following high-cap peers and vice versa. This suggests that the peer effects of R&D intensity are more pronounced within peer groups of similar firms. We perform similar tests for *Tobin's Q* and *firm age* in columns (5) to (12). However, the results are consistent across all three proxies. In all our specifications, the findings further support the rivalry-based channel, as peer effects are stronger among firms belonging to similar groups. These results are in line with the previous research of Adhikari and Agrawal (2018), who demonstrate that groups of similar firms strongly emulate each other's dividend payout policies.

[Insert Table 12 about here]

6.2. R&D peer effects, firm value, and patents

This section examines the economic consequences of firms following peers in R&D intensity, specifically, whether such behavior affects their future value. To address this, we use a two-stage least squares regression (2SLS), using *peers' R&D intensity* as an instrumented variable for the firms' own R&D intensity in the first-stage regression. In the second stage, we use the *instrumented R&D intensity* to predict the firms' future value, which we proxy using *Tobin's Q* one year ahead. The results in columns (1) and (2) of Table 13 suggest that firms that follow peers and adjust their R&D intensity accordingly are likely to achieve higher shareholder wealth in the future. This implies that following peers in R&D intensity can be beneficial for firms.

Furthermore, to validate our previous findings that competition forces firms to follow peers in R&D intensity, we explore the value-increasing relationship in the presence of product market competition. If competition is the force behind R&D peer effects, we expect the value-enhancing relationship to be stronger in firms with high product market competition and weaker in firms with low competition. To test this, we divide our main sample into high- and low-competition firms based on the annual industry median values of product market fluidity and repeat 2SLS estimations for both subsamples. Columns (3) and (4) show the 2SLS estimates for high-competition firms, while columns (5) and (6) report similar results for low-competition firms. As expected, we find positive and significant coefficients for high-competition firms, indicating that following peers in R&D intensity enhances their future value. However, the results are insignificant for low-competition firms in both the first- and second-stage regressions, suggesting that following peers in low-competition contexts does not improve firms' future value. This may explain why firms do not follow their peers in low-competition environments, as seen in Table 9. This evidence further strengthens our earlier claim that the presence of strong competition provides firms with the incentive to follow peers in R&D investments.

Next, we examine whether following peers in R&D leads to an increase in firms' innovation, measured by both the number of patents and their estimated monetary value. Following Kogan et al.

(2017), we use two proxies to measure innovation, one based on the number of patents received by firms in a year, and the other based on the estimated dollar value of those patents. We use a 2SLS regression as before, with firms' R&D intensity instrumented through peers' R&D intensity, and report the second-stage estimation results for both proxies in columns (7) and (8) of Table 13.Our results provide valuable insights into the innovation literature, as we find that following peers in R&D not only increases firms' innovation, as evidenced by a positive and significant association between firms' instrumented R&D intensity and the number of patents received in the following year, but also enhances the estimated value of their patents, as shown in Column (8) of Table 13.

[Insert Table 13 about here]

7. Conclusion

In this paper, we investigate the impact of peer effects on R&D intensity by analyzing how firms respond to the R&D activities of their competitors and rivals. We use a large dataset of 54,393 firm-year observations from US data and find that firms do not make R&D decisions in isolation and that the average industry R&D intensity directly affects their decision to invest in R&D. To ensure the validity of our results, we conduct various robustness checks. Firstly, we rerun our main model using weighted least squares regression as an alternative estimation technique. Secondly, we use two alternate proxies for R&D intensity by employing the total R&D to sales ratio and an R&D-per-employee measure. Later, we also modify our proxy of peers by using three-digit SIC and TNIC-based measures to identify peer firms. Additionally, we change the composition of our main sample by excluding utilities and financial firms and dividing our main sample into two subsamples. Our results remain robust to all these alternative specifications and measuring techniques.

To further validate our results, we check for potential endogeneity by addressing omitted-variable and simultaneity bias. We add three additional control variables, which can potentially impact firms' R&D intensity and/or that of their peers, to check for omitted-variable bias. These variables include firms' cash-holding decisions, market to book value, and financial distress. Even after controlling for all these additional variables individually and simultaneously in a single model, we found significant results for our main hypothesis. To address the issue of potential reverse causality and simultaneity bias, we run 2SLS and dynamic GMM techniques using idiosyncratic stock returns as an instrument. We still find that our main variable of interest, peer effects in R&D, positively influenced the R&D activities of firms.

Next, we examine the reasons why firms imitate each other in R&D. Specifically, we investigate whether information asymmetry and competition have an impact on these R&D peer effects. To do so, we analyze the channels of information asymmetry and product market competition and their roles in R&D peer effects. The results reveal that competition is directly related to R&D peer effects, suggesting that firms mimic their peers' R&D policies only in highly competitive markets. However, regarding the role of information asymmetry, we find mixed evidence, as both low- and high-information asymmetry firms follow their low- and high-information peers, suggesting that the information environment may not be a relevant factor in R&D mimicking. Furthermore, we also find that financial constraints and cross-sectional heterogeneity in firms do not drive our results for R&D mimicking. Lastly, we provide evidence that R&D mimicking is value-enhancing for firms and may increase firms' future patents and the estimated dollar value of those patents.

Our findings suggest that imitating the R&D investments of peers can benefit firms, particularly in highly competitive markets. We conclude that peer R&D is a crucial factor in determining firms' R&D intensity, and that firms should prioritize monitoring their peers' R&D to enhance value and optimize R&D decisions. Our results also have implications for policymakers and regulators. We demonstrate that strong competition is crucial for R&D imitation, which in turn leads to increased patents and firm value. Thus, policymakers and regulators should encourage fair competition within industries to promote innovation and increase shareholder wealth.

Despite these implications, our study has some limitations. Our primary focus is on the US market due to the significant R&D investments made in this country. However, R&D investments are increasing worldwide, especially in Asia. Therefore, a cross-country study that accounts for country-level factors that drive firms' innovation policies would provide a better understanding of R&D peer effects. Additionally, we recommend that future R&D research should consider this important determinant when analyzing firms' R&D and innovation decisions.

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Table 1: Sample description by industry and year

Industry	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Agriculture	7	7	8	8	9	5	6	7	5	6	6	6	5
Food Products	40	43	47	44	46	46	42	49	46	41	32	32	32
Candy & Soda	2	3	5	3	3	5	4	4	4	4	5	6	5
Beer & Liquor	5	6	6	5	5	12	12	11	12	9	7	6	6
Tobacco Products	0	0	0	0	0	2	4	3	2	0	0	0	2
Recreation	13	20	22	24	27	29	27	27	25	18	16	17	16
Entertainment	19	17	25	35	40	45	43	37	36	29	26	33	33
Printing and Publishing	23	20	18	20	21	21	22	23	21	23	17	16	18
Consumer Goods	39	46	54	54	55	61	62	55	48	43	37	35	34
Apparel	27	31	33	39	42	44	42	46	43	37	33	32	31
Healthcare	41	60	58	49	46	48	52	43	37	35	32	39	38
Medical Equipment	58	79	88	87	85	108	132	127	114	100	92	101	97
Pharma Products	56	77	87	92	102	141	149	156	138	145	144	142	147
Chemicals	47	53	52	53	55	48	51	48	46	44	43	44	42
Rubber and Plastic	14	17	19	25	28	31	29	27	23	22	16	17	19
Textiles	19	20	22	25	27	26	27	29	21	14	11	8	7
Construction Material	40	38	47	56	58	64	62	61	51	46	42	38	38
Construction	11	15	11	10	9	17	16	21	15	14	11	9	9
Steel Works	39	38	44	54	56	54	59	57	48	40	33	32	31
Fabricated Products	11	10	10	14	14	13	12	13	8	9	5	4	2
Machinery	75	75	89	92	104	119	124	120	112	104	98	90	89
Electrical Equipment	25	27	31	28	28	36	40	36	35	32	29	26	26
Automobiles and Truck	33	36	42	48	48	49	47	45	39	31	28	29	27
Aircraft	12	13	12	11	12	14	12	14	14	14	14	12	13
Shipbuilding, Railroads	4	4	3	4	5	6	9	10	6	6	4	6	5
Defense	3	3	4	3	5	3	4	4	4	3	2	2	2
Precious Metals	8	9	9	11	11	14	12	9	7	5	5	4	5
Non–Metallic Mining	4	4	6	6	9	9	10	7	7	7	6	5	7
Coal	2	2	0	2	2	2	0	0	0	0	2	3	3
Petroleum and Natural	63	64	76	83	88	102	104	99	97	91	86	89	81
Utilities	49	51	49	49	51	52	59	66	69	69	74	74	76
Communication	32	36	49	63	56	72	73	67	77	71	60	57	58
Personal Services	16	17	21	21	26	30	35	37	38	30	26	22	21
Business Services	76	84	88	93	89	121	142	157	148	152	133	135	125
Computer Hardware	63	68	71	85	86	98	94	82	74	71	62	55	54
Computer Software	82	96	112	121	164	243	263	282	345	365	289	254	237
Electronic Equipment	107	103	123	141	167	184	192	176	163	185	164	163	153
Measuring and Control	41	42	49	56	60	76	83	79	68	72	66	61	59
Business Supplies	39	39	39	43	41	41	42	39	36	27	25	28	24
Shipping Containers	9	9	9	9	10	11	11	10	9	10	9	9	9
Transportation	36	41	46	60	58	67	68	75	68	60	49	48	53
Wholesale	68	68	84	91	97	105	110	114	103	82	71	67	66
Retail	109	138	149	177	183	177	180	164	169	147	124	132	133
Restaurants, Hotels	21	28	38	45	52	58	59	54	54	46	34	41	38
Banking	0	0	0	2	0	2	3	3	4	5	6	7	6
Insurance	28	29	31	31	33	31	29	29	24	23	20	22	19
Real Estate	0	2	0	0	0	0	0	6	7	4	3	3	2
Trading	7	9	9	11	13	16	12	17	12	12	10	12	12
Other	33	35	35	34	30	34	34	34	30	29	22	22	21
	1,556	**1,732**	**1,930**	**2,117**	**2,256**	**2,592**	**2,704**	**2,679**	**2,562**	**2,432**	**2,129**	**2,095**	**2,036**

Table 1 (continued): Sample description by industry and year

Industry	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total	%
Agriculture	5	4	4	4	6	8	9	8	10	8	7	7	165	0.30
Food Products	29	36	37	36	33	38	40	37	42	43	44	44	999	1.84
Candy & Soda	6	7	6	7	8	8	7	7	7	6	7	8	137	0.25
Beer & Liquor	7	6	7	7	6	6	5	6	7	8	8	8	183	0.34
Tobacco Products	3	3	3	3	4	4	4	4	4	4	4	3	56	0.10
Recreation	17	16	15	15	13	14	13	15	12	11	14	13	449	0.83
Entertainment	33	30	32	34	29	28	27	24	27	32	32	29	775	1.42
Printing and Publishing	18	17	16	16	13	13	12	10	12	12	15	16	433	0.80
Consumer Goods	30	31	24	23	29	32	33	32	32	33	36	32	990	1.82
Apparel	30	32	33	27	26	31	35	31	31	29	30	27	842	1.55
Healthcare	43	43	44	42	46	53	50	49	42	45	44	45	1,124	2.07
Medical Equipment	100	106	99	90	85	85	78	76	78	78	88	98	2,329	4.28
Pharma Products	172	172	181	184	161	153	150	155	164	193	254	291	3,806	7.00
Chemicals	43	47	50	49	50	54	51	51	52	56	56	53	1,238	2.28
Rubber and Plastic	19	16	15	12	12	13	14	12	15	14	16	15	460	0.85
Textiles	6	6	3	4	4	7	7	7	8	8	8	8	332	0.61
Construction Material	36	39	38	41	36	46	48	45	43	45	47	45	1,150	2.11
Construction	10	11	15	15	15	17	21	23	23	24	25	23	390	0.72
Steel Works	29	29	27	24	22	24	27	27	29	28	28	27	906	1.67
Fabricated Products	3	3	3	5	6	7	6	6	6	5	5	5	185	0.34
Machinery	91	82	83	79	77	87	84	82	87	83	89	89	2,304	4.24
Electrical Equipment	33	30	26	25	29	30	35	33	35	35	35	42	787	1.45
Automobiles and Truck	28	22	24	22	29	33	36	39	44	43	42	43	907	1.67
Aircraft	12	13	15	14	15	17	16	15	15	16	16	16	347	0.64
Shipbuilding, Railroads	6	7	7	8	7	8	6	7	7	7	8	8	158	0.29
Defense	0	2	3	4	4	4	4	4	4	4	3	6	84	0.15
Precious Metals	6	6	5	4	5	4	7	10	12	12	10	13	203	0.37
Non–Metallic Mining	8	9	8	10	15	14	14	16	17	17	17	19	251	0.46
Coal	3	5	6	5	5	5	7	5	7	5	5	3	79	0.15
Petroleum and Natural	79	85	100	106	101	97	94	88	96	92	100	95	2,256	4.15
Utilities	80	79	81	77	80	82	83	84	78	76	77	83	1,748	3.21
Communication	66	69	65	64	64	62	58	64	65	65	62	68	1,543	2.84
Personal Services	27	28	26	23	26	28	28	30	27	21	26	27	657	1.21
Business Services	126	130	127	108	102	113	112	104	113	116	119	121	2,934	5.39
Computer Hardware	51	45	43	48	46	45	38	41	42	46	49	44	1,501	2.76
Computer Software	245	231	206	206	190	200	192	189	209	221	244	248	5,434	9.99
Electronic Equipment	171	173	163	149	149	146	153	152	154	155	147	134	3,867	7.11
Measuring and Control	61	65	58	55	51	52	49	46	47	45	46	46	1,433	2.63
Business Supplies	25	26	26	25	29	28	29	27	29	27	25	24	783	1.44
Shipping Containers	10	9	9	8	8	9	9	9	9	9	9	10	232	0.43
Transportation	63	66	65	59	57	68	71	67	67	67	66	59	1,504	2.77
Wholesale	65	64	63	53	54	60	65	69	73	73	78	78	1,921	3.53
Retail	134	135	122	112	111	122	129	125	127	138	136	134	3,507	6.45
Restaurants, Hotels	41	43	41	39	35	40	43	40	43	47	52	58	1,090	2.00
Banking	5	5	8	5	6	5	4	4	5	3	4	3	95	0.17
Insurance	19	17	20	13	17	15	16	15	13	15	13	15	537	0.99
Real Estate	3	5	2	4	4	5	4	5	5	5	7	4	80	0.15
Trading	13	19	21	23	16	20	26	27	29	24	35	40	445	0.82
Other	26	27	31	34	30	30	34	33	33	32	28	26	757	1.39
	2,136	**2,151**	**2,106**	**2,020**	**1,966**	**2,070**	**2,083**	**2,055**	**2,136**	**2,181**	**2,316**	**2,353**	**54,393**	**100**

Table 2 Summary statistics

	Observations	Mean	Std. Dev.	Minimum	5th Percentile	25th Percentile	Median	75th Percentile	95th Percentile	Maximum
Dependent variable										
R&D Intensity	54,393	0.054	0.101	0.000	0.000	0.000	0.003	0.069	0.257	0.575
Peer Averages of dependent										
Peer R&D Intensity	54,393	0.054	0.068	0.000	0.000	0.003	0.019	0.096	0.227	0.309
Firm characteristics										
Size	54,393	6.037	1.849	2.367	3.276	4.660	5.861	7.271	9.446	10.699
Tobin's Q	54,393	2.150	1.661	0.651	0.846	1.161	1.588	2.447	5.543	10.391
Tangibility	54,393	0.271	0.232	0.006	0.025	0.086	0.196	0.395	0.774	0.892
Leverage	54,393	0.209	0.206	0.000	0.000	0.014	0.171	0.331	0.598	0.931
Capex	54,393	0.060	0.062	0.001	0.006	0.021	0.041	0.075	0.190	0.345
Institutional Ownership	54,393	0.518	0.260	0.020	0.087	0.301	0.536	0.738	0.911	1.000
Analyst Coverage	54,393	8.588	8.013	1.000	1.000	3.000	6.000	12.000	26.000	37.000
Peer averages of firm characteristics										
Size	54,393	6.037	0.946	3.519	4.621	5.324	5.972	6.674	7.647	10.566
Tobin's Q	54,393	2.150	0.801	0.698	1.236	1.606	1.917	2.493	3.756	8.023
Tangibility	54,393	0.271	0.178	0.016	0.075	0.139	0.220	0.332	0.685	0.857
Leverage	54,393	0.209	0.092	0.000	0.081	0.136	0.200	0.264	0.385	0.815
Capex	54,393	0.060	0.036	0.004	0.026	0.036	0.052	0.071	0.145	0.224
Institutional Ownership	54,393	0.518	0.124	0.095	0.335	0.406	0.524	0.621	0.706	0.975
Analyst Coverage	54,393	8.588	2.733	1.000	4.833	6.590	8.319	10.110	13.760	26.286

This table shows summary statistics of the dependent, independent, and control variables used in our main regressions. The sample consists of all the US Firms available on Compustat from 1991 to 2015. *R&D Intensity* is measured as the ratio of R&D expenditure to total Assets. *Peer R&D Intensity* is the annual ratio of industry R&D intensity (except the firm *i*) based on Fama and French 49 Industry classification, *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is performance measure defined as Firm *i's* market to book during fiscal year t, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year t.

Table 3 Pearson correlation

	R&D Intensity	Peer R&D Intensity	Size	Tobin's Q	Tangibility	Leverage	Capex	Institutional Ownership	Analyst Coverage	VIF
R&D Intensity	1									–
Peer R&D Intensity	0.535***	1								1.38
Size	–0.291***	–0.274***	1							3.34
Tobin's Q	0.329***	0.344***	–0.200***	1						1.28
Tangibility	–0.246***	–0.418***	0.252***	–0.245***	1					2.28
Leverage	–0.159***	–0.256***	0.283***	–0.202***	0.341***	1				1.27
Capex	–0.107***	–0.230***	–0.003	–0.013***	0.632***	0.111***	1			1.86
Institutional Ownership	–0.132***	–0.081***	0.567***	–0.050***	–0.020***	0.012***	–0.079***	1		1.57
Analyst Coverage	–0.073***	–0.039***	0.703***	0.085***	0.126***	0.050***	0.0781***	0.458***	1	2.41

This table shows Pearson correlations of the dependent, independent, and control variables used in our main regressions. The sample consists of all the US firms available on Compustat from 1991 to 2015. *R&D intensity* is measured as the ratio of R&D expenditure to total assets, *Peer R&D Intensity* is the annual ratio of industry R&D intensity (except the firm *i*) based on Fama and French 49 Industry classification, *Size* is defined as natural logarithm of total assets, *Tobin's Q* is performance measure defined as Firm *i's* market to book during fiscal year t, calculated as market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as average number of Analyst providing estimates for firm's EPS during the year t, Subscript *, **, *** represents significance at 10%, 5% and 1% level, respectively.

Table 4: Peer effect in R&D intensity

Variables	(1) Main independent and Size	(2) Pooled OLS	(3) Weighted Least Square
Peer R&D Intensity	0.537***	0.516***	0.523***
	(9.26)	(9.37)	(12.48)
Size	–0.012***	–0.017***	–0.017***
	(–20.80)	(–21.44)	(–46.88)
Tobin's Q		0.007***	0.007***
		(12.40)	(20.34)
Tangibility		–0.018***	–0.018***
		(–4.31)	(–8.61)
Leverage		0.007*	0.007***
		(1.69)	(3.01)
Capex		–0.024**	–0.025***
		(–2.33)	(–3.44)
Institutional Ownership		–0.009***	–0.009***
		(–2.70)	(–5.78)
Analyst Coverage		0.002***	0.002***
		(14.41)	(30.88)
Constant	0.080***	0.119***	0.128***
	(5.89)	(6.11)	(10.60)
Observations	54,393	54,393	54,393
Peer averages of firm characteristics	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Adj R2	0.478	0.504	0.505
F-Stat	64.22***	67.77***	341.37***

This table reports the results of regressing the R&D intensity of the firm on peer firms' R&D. The sample consists of all the US firms from 1991 to 2015. The main variable of interest is *Peer R&D intensity* (R&D expenditure to total assets) based on Fama and French 49 Industry Classification. *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is a performance measure defined as the Firm *i's* market to book during fiscal year *t*, calculated as the market value of equity plus the book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t*. Column (1) shows the results of OLS regression for the main independent variable and size, column (2) shows the result of pooled OLS regression for the whole model, in column (3), we use weighted least square regression where weights are based on the annual number of observations. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 5: Alternate proxies for R&D intensity

Variables	(1) R&D to total Sales	(2) R&D per employee	(3) R&D to capital expenditure	(4) R&D to operating expense
Peer R&D Intensity	0.339***	0.843***	0.894***	0.267***
	(2.71)	(10.09)	(11.36)	(3.20)
Size	–0.040***	–0.012***	–2.568***	–0.020***
	(–9.73)	(–8.52)	(–15.41)	(–11.04)
Tobin's Q	0.019***	0.003**	0.390***	0.008***
	(6.27)	(2.54)	(3.06)	(7.62)
Tangibility	–0.139***	–0.074***	–5.217***	–0.132***
	(–6.56)	(–4.89)	(–4.77)	(–9.75)
Leverage	0.021	–0.002	1.930**	–0.032***
	(0.98)	(–0.28)	(2.10)	(–3.44)
Capex	–0.088*	–0.046	–58.827***	–0.022
	(–1.76)	(–1.17)	(–18.71)	(–0.73)
Institutional Ownership	–0.035*	–0.013	–2.877***	0.005
	(–1.85)	(–1.59)	(–3.74)	(0.56)
Analyst Coverage	0.003***	0.002***	0.211***	0.003***
	(4.39)	(7.46)	(8.78)	(9.80)
Constant	0.252**	0.141***	20.003***	0.186***
	(2.31)	(6.34)	(7.01)	(3.27)
Observations	53,828	33,670	33,987	34,079
Peer averages of firm characteristics	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Adj R2	0.370	0.240	0.356	0.562
F-Stat	28.69***	17.34***	26.76***	48.12***

This table reports the results of regressing the R&D intensity of the firm on peer firms' R&D based on alternate measures of the R&D Intensity of the firm. The sample consists of all the US firms from 1991 to 2015. The main variable of interest is *Peer R&D intensity*, calculated as the mean R&D intensity based on Fama and French 49 Industry Classification using various R&D intensity proxies mentioned in each column. *Size* is defined as the nature logarithm of total assets. *Tobin's Q* is a performance measure defined as the Firm *i's* market to book during fiscal year *t*, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t*. Columns (1) to (4) show results of OLS regressions using the proxy of R&D to Sales, R&D per employee, R&D to capital assets, and R&D to operating expense, respectively, as a measure of the firm's *R&D intensity*. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 6: Alternate proxies for peers, sample, and model specifications

Variables	(1) Without zero R&D to total asset	(2) TNIC based Peers	(3) SIC based Peers	(4) Median R&D to total assets	(5) Sample Split: High-tech	(6) Sample Split: Non-high-tech	(7) Excluding Financial & Utility firms and the crisis period
Peer R&D Intensity	0.267***	0.868***	0.289***	0.527***	0.486***	0.141*	0.531***
	(5.02)	(30.74)	(6.38)	(8.63)	(6.06)	(1.66)	(9.48)
Size	–0.032***	–0.018***	–0.018***	–0.017***	–0.035***	–0.003***	–0.018***
	(–25.82)	(–21.23)	(–22.42)	(–21.40)	(–24.13)	(–6.36)	(–21.40)
Tobin's Q	0.007***	0.007***	0.007***	0.007***	0.008***	0.004***	0.008***
	(10.57)	(10.75)	(12.34)	(12.45)	(10.34)	(4.61)	(12.45)
Tangibility	–0.056***	–0.013**	–0.024***	–0.018***	–0.053***	–0.018***	–0.017***
	(–4.89)	(–2.43)	(–4.79)	(–4.32)	(–3.99)	(–7.74)	(–3.57)
Leverage	0.028***	0.017***	0.007	0.006*	0.021***	–0.009***	0.008**
	(4.01)	(3.69)	(1.64)	(1.66)	(2.70)	(–3.93)	(1.99)
Capex	0.101***	–0.020*	–0.017	–0.025**	0.056*	0.013**	–0.020*
	(3.77)	(–1.74)	(–1.59)	(–2.42)	(1.86)	(2.10)	(–1.73)
Institutional Ownership	–0.014**	–0.016***	–0.007**	–0.009***	–0.006	–0.004**	–0.009***
	(–2.54)	(–4.59)	(–2.13)	(–2.76)	(–1.04)	(–2.00)	(–2.63)
Analyst Coverage	0.003***	0.002***	0.002***	0.002***	0.004***	0.000***	0.002***
	(15.52)	(12.19)	(14.76)	(14.44)	(15.62)	(5.62)	(14.42)
Constant	0.267***	–0.003	0.164***	0.133***	0.176***	0.050***	0.128***
	(5.02)	(–0.37)	(10.38)	(7.95)	(4.65)	(3.29)	(5.75)
Observations	28,101	43,430	53,521	54,267	23,634	30,759	45,990
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.451	0.603	0.513	0.504	0.418	0.213	0.501
F-Stat	37.56***	57.23***	46.21***	44.79***	32.68***	15.12***	44.32***

This table reports the results of regressing the R&D intensity of the firm on peer firms' R&D based on alternate measures of the R&D Intensity of the firm. The sample consists of all the US firms from 1991 to 2015. The main variable of interest is *Peer R&D intensity*, based on three different proxies of peers based on three digits SIC codes (in column 1), TNIC-based peers (in column 2), and Fama & French 49 industries (in column 3 to column 6). *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is a performance measure defined as the Firm *i's* market to book during fiscal year *t*, calculated as the market value of equity plus book value of assets minus the book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t*. In column (1), we remove firm-year observations with zero R&D intensity and rerun our baseline OLS regression using R&D to total assets as a proxy for R&D intensity. Column (2) and column (3) show the result using text-based network industrial classification (TNIC) and three-digit standard industry classifications as an alternate proxy for peer composition. Column (4) shows the regression results using *Peer median R&D intensity* (measured as the annual median R&D intensity of all the firms in the industry except the firm itself) as a main variable of interest. Column (5) shows the results of regression using *peer R&D Intensity* as a measure of R&D intensity for a sample of nine high–tech industries wherein high–tech industries include business services, computers, computer software, electrical equipment, electronic equipment, measuring and control equipment, medical equipment, pharmaceutical products, and telecommunication identified by Fama and French's (1997) 49–industry classification. Column (6) shows the regression results using *peer R&D Intensity* as a measure of R&D intensity for a sample of firms excluding the nine high–tech industries identified by Fama and French's (1997) 49–industry classification. Column (7) shows the result of the alternate sample composition by excluding financial / utility firms and the financial crisis period of 2008 and 2009. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 7: Additional control variables

Variables	(1) *Cash Holdings*	(2) *Market to Book*	(3) *Distress Risk*	(4) Controlling for MSA R&D Intensity	(5) All additional controls
Peer R&D Intensity	0.500***	0.507***	0.539***	0.505***	0.527***
	(9.24)	(9.13)	(9.59)	(9.18)	(9.19)
Size	–0.015***	–0.015***	-0.016***	–0.017***	-0.013***
	(–20.30)	(–20.12)	(-20.02)	(–21.13)	(-17.67)
Tobin's Q	0.006***	0.002**	0.013***	0.007***	0.007***
	(9.69)	(2.12)	(14.03)	(11.81)	(5.69)
Tangibility	–0.006	–0.016***	-0.016***	–0.009**	0.005
	(–1.39)	(–3.99)	(-3.69)	(–2.02)	(1.05)
Leverage	0.018***	–0.028***	-0.017***	0.012***	-0.021***
	(4.56)	(–7.71)	(-3.42)	(3.01)	(-5.09)
Capex	–0.022**	–0.031***	-0.038***	–0.028***	-0.047***
	(–2.18)	(–3.17)	(-3.63)	(–2.58)	(-4.64)
Institutional Ownership	–0.007**	–0.006*	-0.007**	–0.009***	-0.004
	(–2.28)	(–1.95)	(-1.97)	(–2.76)	(-1.36)
Analyst Coverage	0.002***	0.002***	0.002***	0.002***	0.001***
	(14.23)	(13.52)	(12.01)	(13.20)	(10.16)
Cash Holdings	0.092***	–	–	–	0.082***
	(14.73)	–	–	–	(13.14)
Market to Book	–	0.002***	–	–	0.001***
	–	(9.34)	–	–	(5.43)
Distress Risk	–	–	-0.002***	–	-0.002***
	–	–	(-7.06)	–	(-6.45)
MSA R&D Intensity	–	–	–	0.304***	0.280***
	–	–	–	(14.07)	(13.23)
Constant	0.096***	0.117***	0.114***	0.096***	0.078***
	(5.49)	(6.29)	(5.90)	(4.84)	(4.70)
Observations	54,066	52,406	50,673	49,562	44,405
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes
Adj R2	0.516	0.499	0.533	0.523	0.549
F–stat	72.25***	66.14***	75.91***	48.56***	77.76***

This table reports the results of regressing the R&D intensity of the firm on peer firms' R&D with additional control variables. The sample consists of all the US firms from 1991 to 2015. The main variable of interest is *Peer R&D intensity*, based on a proxy of peers based on Fama & French 49 industries. *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is a performance measure defined as the Firm *i's* market to book during fiscal year t, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, capex is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of analysts providing estimates for firms' EPS during the year t. *Cash Holdings* is the ratio of cash to total assets, *Market to Book* is the ratio of the market value of the equity divided by the book value of equity, Altman's Z–score is the proxy for the firm's *Distress Risk* and *MSA R&D Intensity* is the annual average R&D intensity within the MSA of a firm's headquarter. We exclude the firm itself in calculating the average MSA R&D intensity. In each model, using one of the additional control variables as mentioned at the top of each column, we run pooled OLS regression with firm-level cluster effect, while in the last model specification, we run regression using all the additional control variables. Variable descriptions are defined in detail in Appendix–A. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 8 Addressing endogeneity

Variables	Firm fixed effects			2 stage least square			System GMM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(7)
	R&D to total assets	R&D to sales	R&D per employee	R&D to total assets	R&D to Net sales	R&D per employee	R&D to total assets	R&D to Net sales	R&D per employee
Peer R&D to total assets	0.335***	–	–	2.461***	–	–	1.606***	–	–
	(6.90)	–	–	(3.57)	–	–	(2.89)	–	–
Peer R&D to sales	–	0.544***	–	–	1.765***	–	–	0.604*	–
	–	(4.16)	–	–	(2.80)	–	–	(1.77)	–
Peer R&D per employee	–	–	0.557***	–	–	0.756***	–	–	0.298**
	–	–	(3.87)	–	–	(4.81)	–	–	(2.25)
Lagged R&D to total assets	–	–	–	–	–	–	0.457***	–	–
	–	–	–	–	–	–	(8.65)	–	–
Lagged R&D to sales	–	–	–	–	–	–	–	0.538***	–
	–	–	–	–	–	–	–	(8.57)	–
Lagged R&D per employee	–	–	–	–	–	–	–	–	0.561***
	–	–	–	–	–	–	–	–	(11.17)
Constant	0.125***	-0.194**	51.314***	–0.199*	0.163	0.077**	–0.804*	–1.387	0.053
	(10.54)	(-2.07)	(22.23)	(–1.80)	(1.38)	(2.49)	(–1.91)	(–0.66)	(0.68)
<u>1st stage regression</u>									
Peer Idiosyncratic Stock returns	–	–	–	0.821***	4.924***	3.283***	–	–	–
	–	–	–	(6.89)	(8.90)	(12.05)	–	–	–
Observations	54,393	53,828	33,670	52,633	52,224	32,586	43,873	43,550	26,934
Firm-specific characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effect	Yes	Yes	Yes	No	No	No	No	No	No
Adj R2	0.851	0.764	0.686	0.452	0.350	0.545	–	–	–
F–stat	14.95***	2.736***	7.47***	59.82***	25.28***	33.54***	43.89***	7.232***	36.42***
Cragg-Donald Wald F statistic (1st stage)	–	–	–	83.10***	186.22***	293.97 ***	–	–	–
Kleibergen-Paap rk LM statistic (1st stage)	–	–	–	47.01***	76.27***	143.90***	–	–	–
AR(1) test (p-value)	–	–	–	–	–	–	0.000	0.000	0.000
AR(2) test (p-value)	–	–	–	–	–	–	0.238	0.129	0.713
Hensen–J (p-value)	–	–	–	–	–	–	0.367	0.156	0.419

This table reports the results of Instrumental variable analysis for peer effect in R&D using idiosyncratic stock returns of peer firms as an instrument. The sample consists of all the US firms from 1991 to 2015. The main variable of interest is Peer R&D intensity, with three proxies of *Peer R&D to total assets*, *Peer R&D to net sales*, and *Peer R&D per employee*, where peers are composed using Fama and French 49 Industry Classification. *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is a performance measure defined as the Firm *i's* market to book during fiscal year *t*, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t*. Columns (1) to (3) report the results of firm fixed effects. Column (4) to column (6) reports the results of regression using 2SLS, while columns (7) to (9) shows the result using systematic GMM equations with instrument variable. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 9: Competition and peer R&D intensity

Variables	TNIC based HHI		Product market Similarity		Product market Fluidity	
	(1) Low TNIC HHI (High Competition)	(2) high TNIC HHI (low Competition)	(3) high Similarity (High Competition)	(4) low Similarity (low Competition)	(5) High Fluidity (High Competition)	(6) Low Fluidity (Low Competition)
Peer R&D Intensity	0.414***	–0.013	0.400***	–0.093	0.508***	0.091
	(7.57)	(–0.17)	(6.06)	(–1.50)	(6.56)	(1.03)
Size	–0.024***	–0.011***	–0.027***	–0.007***	–0.028***	–0.007***
	(–19.51)	(–12.42)	(–20.54)	(–9.48)	(–21.15)	(–9.12)
Tobin's Q	0.008***	0.007***	0.008***	0.005***	0.008***	0.005***
	(9.72)	(7.49)	(9.68)	(5.52)	(9.27)	(5.10)
Tangibility	–0.020***	–0.018***	–0.008	–0.013***	–0.018**	–0.014***
	(–2.85)	(–3.60)	(–1.03)	(–3.70)	(–2.22)	(–4.14)
Leverage	0.018***	–0.006	0.019***	–0.006	0.018***	–0.009**
	(3.01)	(–1.43)	(3.07)	(–1.43)	(2.69)	(–2.36)
Capex	–0.061***	–0.003	–0.077***	0.023	–0.080***	–0.002
	(–3.99)	(–0.14)	(–4.85)	(1.34)	(–4.45)	(–0.15)
Institutional Ownership	–0.018***	–0.010***	–0.024***	–0.005	–0.018***	–0.006*
	(–3.46)	(–2.76)	(–4.26)	(–1.52)	(–3.33)	(–1.77)
Analyst Coverage	0.002***	0.001***	0.002***	0.001***	0.003***	0.001***
	(11.87)	(8.48)	(12.20)	(6.01)	(13.64)	(6.49)
Constant	0.160***	0.063***	0.139***	0.069***	0.169***	0.048***
	(6.56)	(3.10)	(4.92)	(4.79)	(4.09)	(3.04)
Observations	21,155	21,257	21,133	21,247	19,895	19,895
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.576	0.376	0.566	0.288	0.532	0.370
F–stat	58.41***	25.04***	65.30***	16.19***	55.21***	20.10***

This table reports the results for peer effect in R&D in Sub-samples of high and low-competitive markets. The sample consists of all the US firms from 1996 to 2015. Low- and high-competition Sub-samples are categorized based on the median values of each proxy of product market competition, including TNIC-based HHI, Similarity Index, and Product Fluidity. The main variable of interest is *Peer R&D intensity*, measured as R&D to total assets, where peers are composed using Fama and French 49 Industry Classification *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is performance measure defined as Firm *i's* market to book during fiscal year *t*, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t*. Column (1), column (3), and column (5) report the results of regression using 2SLS for the markets with high competition, while column (2), column (4), and column (6) shows similar results for low competition. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 10: Information asymmetry and peer R&D intensity

VARIABLES	Analyst coverage (1) high information asymmetry firm's reaction to its high information asymmetry peers	(2) high information asymmetry firm's reaction to its less information asymmetric peers	(3) low information asymmetry firm's reaction to its low information asymmetry peers	(4) low information asymmetry firm's reaction to its high information asymmetry peers	Bid–Ask spread (5) high information asymmetry firm's reaction to its high information asymmetry peers	(6) high information asymmetry firm's reaction to its less information asymmetric peers	(7) low information asymmetry firm's reaction to its low information asymmetry peers	(8) low information asymmetry firm's reaction to its high information asymmetry peers
High information asymmetric peers R&D intensity	0.291***	–	–	0.372***	0.448***	–	–	0.222***
	(5.06)	–	–	(7.36)	(8.23)	–	–	(5.37)
Low information asymmetric peers R&D intensity	–	0.380***	0.493***	–	–	0.544***	0.376***	–
	–	(5.53)	(8.39)	–	–	(6.64)	(7.04)	–
Size	–0.019***	–0.019***	–0.017***	–0.016***	–0.020***	–0.020***	–0.014***	–0.014***
	(–18.55)	(–18.49)	(–16.27)	(–16.16)	(–18.64)	(–18.62)	(–15.31)	(–15.19)
Tobin's Q	0.010***	0.010***	0.005***	0.005***	0.011***	0.011***	0.006***	0.006***
	(11.74)	(11.71)	(6.59)	(6.90)	(11.18)	(10.96)	(8.57)	(9.11)
Tangibility	–0.017***	–0.017***	–0.017***	–0.017***	–0.020***	–0.021***	–0.017***	–0.017***
	(–3.16)	(–3.11)	(–3.19)	(–3.23)	(–3.79)	(–3.93)	(–3.52)	(–3.57)
Leverage	0.015***	0.015***	–0.001	–0.001	0.010**	0.010**	0.003	0.003
	(3.19)	(3.13)	(–0.11)	(–0.12)	(2.30)	(2.21)	(0.60)	(0.55)
Capex	–0.016	–0.015	–0.053***	–0.053***	–0.027*	–0.024*	–0.021	–0.019
	(–1.17)	(–1.14)	(–3.71)	(–3.76)	(–1.93)	(–1.76)	(–1.59)	(–1.47)
Institutional Ownership	–0.002	–0.001	–0.022***	–0.021***	0.007	0.006	–0.010**	–0.010**
	(–0.38)	(–0.26)	(–4.63)	(–4.45)	(1.59)	(1.46)	(–2.32)	(–2.22)
Analyst Coverage	0.004***	0.004***	0.001***	0.001***	0.003***	0.003***	0.001***	0.001***
	(11.13)	(11.25)	(9.64)	(9.06)	(12.20)	(11.97)	(11.45)	(11.05)
Constant	0.118***	0.103***	0.130***	0.149***	0.130***	0.149***	0.097***	0.098***
	(5.31)	(4.48)	(5.62)	(7.29)	(6.33)	(6.19)	(5.24)	(5.76)
Observations	29,262	29,271	24,914	24,981	26,559	26,626	26,403	26,426
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.496	0.497	0.539	0.535	0.523	0.521	0.512	0.510
F–stat	49.23***	49.63***	42.06***	41.05***	52.36***	53.12***	42.12***	41.21***

This table reports the results of regressing the R&D intensity of the firm on peer firms' R&D based on a subsample of firms having different magnitudes of information asymmetry. The sample consists of all the US firms from 1991 to 2015. *High (low) information asymmetric peers R&D intensity* is measured as the average R&D intensity of firms with the FF–49 industry having less than or equal to the median (greater than the median) number of within industry–year analyst coverage or having higher than the median (less than or equal to median) bid-ask spread. *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is a performance measure defined as the Firm *i's* market to book during fiscal year *t*, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by the book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t.* In columns (1) to (4), we report the results of regression for high (low) information asymmetry based on analyst coverage, wherein firms are considered as high (low) information asymmetric if the number of analysts following a firm is less than or equal to median (greater than the median) number of analysts within the industry-year. In columns (5) to (8), we report the results of regression for high (low) information asymmetry based on Bid-Ask spread, wherein firms are considered as high (low) information asymmetric if the Bid-Ask spread of a firm is higher than (less than or equal to median) of the Bid-Ask spread within the industry-year. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 11: Financial Constraint and R&D peer effects

Variables	KZ index	WW Index	SA index	Text-based Constraint index

	(1) Non–constraint	(2) Constraint	(3) Non–constraint	(4) Constraint	(5) Non–constraint	(6) Constraint	(7) Non-constraint	(8) Constraint
Peer R&D Intensity	0.276***	0.799***	0.373***	0.710***	0.195**	0.634***	0.420***	0.588***
	(4.92)	(9.80)	(6.90)	(8.70)	(2.36)	(7.30)	(5.30)	(6.42)
Size	–0.012***	–0.018***	–0.009***	–0.021***	–0.011***	–0.021***	–0.017***	–0.021***
	(–14.15)	(–18.79)	(–10.50)	(–17.94)	(–8.45)	(–17.86)	(–15.52)	(–16.69)
Tobin's Q	0.003***	0.010***	0.004***	0.009***	0.009***	0.008***	0.009***	0.008***
	(5.78)	(11.51)	(6.09)	(12.53)	(6.41)	(10.40)	(8.62)	(8.88)
Tangibility	–0.024***	–0.016***	–0.018***	–0.021***	–0.019**	–0.023***	–0.028***	–0.010
	(–4.89)	(–3.12)	(–4.09)	(–3.86)	(–2.40)	(–3.44)	(–4.07)	(–1.35)
Leverage	0.024***	–0.058***	–0.008*	0.020***	0.013	0.018***	0.016**	0.012**
	(4.13)	(–9.35)	(–1.75)	(4.28)	(1.50)	(3.39)	(2.50)	(2.02)
Capex	0.023*	–0.034**	0.012	–0.002	–0.029	–0.021	–0.029	–0.047**
	(1.84)	(–2.45)	(0.93)	(–0.16)	(–1.17)	(–1.23)	(–1.53)	(–2.47)
Institutional Ownership	0.001	–0.010**	–0.003	0.010**	–0.004	–0.000	–0.007	–0.021***
	(0.24)	(–2.57)	(–0.90)	(2.42)	(–0.51)	(–0.02)	(–1.46)	(–4.20)
Analyst Coverage	0.001***	0.002***	0.001***	0.003***	0.002***	0.002***	0.002***	0.002***
	(10.97)	(12.00)	(9.11)	(12.41)	(6.83)	(12.24)	(10.20)	(11.31)
Constant	0.107***	0.121***	0.062***	0.114***	0.087***	0.089***	0.115***	0.124***
	(4.92)	(4.73)	(3.14)	(3.89)	(2.78)	(2.82)	(4.55)	(3.58)
Observations	26,714	26,800	24,897	28,340	11,704	24,797	16,603	16,604
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.457	0.589	0.477	0.546	0.482	0.537	0.480	0.555
F–stat	45.99***	70.34***	32.08***	69.75***	22.45***	71.60***	33.38***	53.64***

This table reports the results of regressing the R&D intensity of the firm on peer firms' R&D in the presence of financial constraints. The sample consists of all the US firms from 1997 to 2015. The main variable of interest is peer R&D intensity (R&D expenditure to total assets) based on Fama and French 49 Industry Classification. Firms are divided into non-constraint and constraint based on the median values of the respective constraint index, wherein values higher than the median represent constraint firms and vice versa. *Size* is defined as the natural logarithm of total assets, *Tobin's Q* is a performance measure defined as the Firm *i's* market to book ratio during fiscal year *t*, calculated as the market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes (set to zero if missing), divided by book value of assets, *Tangibility* is defined as fixed assets scaled by total assets, *Leverage* is defined as the book value of debt divided by book value of total assets, *Capex* is defined as capital expenditure divided by the book value of total assets, *Institutional Ownership* is the percentage of shares held by institutional owners taken from Thomson Reuters, and *Analyst Coverage* is measured as the average number of Analyst providing estimates for firm's EPS during the year *t*. Columns (1) to column (8) show the regression results for non–constraint and constraint firms (as mentioned in the column) based on four proxies of the KZ index, WW Index, SA index, and text-based constraint index, respectively. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 12: Leader vs. followers based on Market capitalization, growth, and firm age

	Market capitalization				Growth (Tobin's Q)				Firm age			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Low		High		Low		High		Young		Old	
Peer R&D Intensity ^{low}	0.415***		0.003***		0.502***		0.280***					
	(7.06)		(6.97)		(8.52)		(6.03)					
Peer R&D Intensity ^{high}		0.008***		0.379***		0.330***		0.323***				
		(7.89)		(6.17)		(5.62)		(4.88)				
Peer R&D Intensity ^{Young}									0.495***		0.282***	
									(8.40)		(3.39)	
Peer R&D Intensity ^{Old}										0.487***		0.278***
										(6.23)		(5.14)
Constant	0.102***	0.086***	0.100***	0.111***	0.089***	0.155***	0.072***	0.136***	0.104***	0.130***	0.137***	0.103***
	(4.63)	(4.86)	(6.78)	(5.61)	(5.73)	(6.53)	(4.83)	(5.20)	(5.01)	(5.02)	(6.29)	(3.76)
Observations	26,592	26,612	26,021	25,965	26,592	25,965	26,612	26,021	29,704	28,161	24,623	24,670
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.524	0.525	0.516	0.514	0.484	0.524	0.478	0.524	0.539	0.534	0.482	0.483
F–stat	47.12***	48.40***	36.06***	36.24***	42.52***	46.66***	42.14***	46.15***	60.67***	60.23***	28.71***	29.49***

This table reports the results of regressing R&D intensity of the firm on peer firms' R&D for leaders and followers. The sample consists of all the US firms from 1991 to 2015. The main variable of interest is peer R&D intensity (R&D expenditure to total assets) based on Fama and French 49 Industry Classification. Firms are divided into low (high) based on the annual industry median values of market capitalization, Tobin's Q, and market share, respectively. Column (1) to column (4) shows the reaction of low and high-market capitalization firms to low and high-market capitalization peers. Column (5) to column (8) shows the reaction of low and high-growth firms to low and high-growth peers, respectively. Lastly, Column (9) to column (12) shows the reaction of young and old firms to young and old market peers, respectively. Subscript *, **, *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 13: R&D peer effects, firm value, and patents

	Tobin's Q (t+1) Full sample		High competition Product market fluidity > median		Low competition Product market fluidity < median		Patents (t+1) Full sample	Value of patents (t+1) Full sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	2nd stage	2nd stage

	R&D Intensity (t)	Tobin Q (t+1)	R&D Intensity (t)	Tobin Q (t+1)	R&D Intensity (t)	Tobin Q (t+1)	Patents (t+1)	Value of patents (t+1)
Peer R&D Intensity	0.504***	–	0.705***	–	0.187	–	–	–
	(8.45)	–	(8.00)	–	(1.46)	–	–	–
R&D Intensity (Instrumented)		9.406***	–	10.199***	–	5.704	1.760***	2.840***
		(6.60)	–	(4.92)	–	(1.22)	(3.36)	(5.84)
Constant	0.116***	–0.182	0.112***	–0.241	0.146***	0.183	–1.504***	–4.915***
	(5.98)	(–0.58)	(4.05)	(–0.42)	(5.10)	(0.22)	(–2.97)	(–6.45)
Observations	44695	44,695	21,521	17,206	20,217	16,441	19,289	19,289
Firm-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peer averages of firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Cluster effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.510	0.488	0.584	0.445	0.451	0.605	0.786	0.949

This table presents the two-stage least square regression estimating the relationship between R&D intensity and firm value. In the first stage regression, the dependent variable is the firm's *R&D Intensity,* and the independent variable is the *peer R&D Intensity,* wherein peers are based on Fama and French 49 industry classification. Column (1) and column (2) report the results of 1st and 2nd stage regression of two-stage least squares (2SLS) estimating the relationship between R&D intensity and firm value using *peer R&D intensity* as an instrument for a firm's *R&D intensity.* In the second stage regression, the dependent variable is one-year lead *Tobin's Q* and the independent variable is instrumented R&D Intensity from first stage regression. Column (3) and column (4) report a similar 2SLS regression for a subsample of high-competition firms based on annual industry *product market Fluidity.* A firm is categorized as highly competitive if its *product market fluidity* score exceeds the annual industry median *product market Fluidity.* Column (5) and column (6) reports the 2SLS regression for a subsample of low-competition firms based on annual industry *product market Fluidity.* A firm is categorized as low competitive if its *product market fluidity* score is lower than the annual industry median *product market Fluidity.* In columns (7) and (8), we report the 2nd stage estimation results for 2SLS regression wherein the dependent variable is the one-year lead natural logarithm of the number of patents & natural log of the dollar value of patents for the firm *i,* respectively, and the independent variable is instrumented R&D Intensity from first stage regression.

Appendix A: Definition of variables

Variable	Description	Data source
Dependent variable		
R&D Intensity	R&D expenditure to total assets	Compustat
Independent variable		
Peer R&D Intensity	Average R&D intensity of the industry using Fama and French 49 industry classification as a proxy for peers	Authors' calculation.
Firm-specific variables		
Size	Log of total assets.	Compustat
Tobin's Q	Firm's market to book = (market value of equity + book value of assets –book value of equity – balance sheet deferred taxes (set to zero if missing))/book value of assets.	Compustat
Tangibility	Fixed assets to total assets.	Compustat
Leverage	Book value of debt to book value of total assets.	Compustat
Capex	Capital expenditure to total assets.	Compustat
Institutional Ownership	Percentage of institutional Ownership in a firm.	Thomson Reuters
Analyst Coverage	Number of analysts providing EPS estimates for the next year.	Institutional Brokers Estimate System I/B/E/S
Peer firms averages of firm-specific variables		
Size	The average size of the industry using Fama and French 49 industry classification.	Authors calculations
Tobin's Q	Average Tobin's Q of the industry using Fama and French 49 industry classification.	Authors calculations
Tangibility	The average tangibility of the industry using Fama and French 49 industry classification.	Authors calculations
Leverage	Average leverage of the industry using Fama and French 49 industry classification.	Authors calculations
Capex	Average Capex ratio of the industry using Fama and French 49 industry classification.	Authors calculations
Institutional Ownership	Average Intuitional Ownership of the industry using Fama and French 49 industry classification.	Authors calculations
Analyst Coverage	Average Analyst coverage of the industry using Fama and French 49 industry classification.	Authors calculations
Product market Competition proxies		
TNIC based HHI	The Herfindahl index calculated as the sum of the squared market shares using firm sales. It is based on the TNIC industry classification of Hoberg and Phillips.	Hoberg–Phillips Data library available at https://hobergphillips.tuck.dartmouth.edu/
Product Market Similarity	The product market similarity index measures the similarity between a firm's product descriptions and those of industry peers using the TNIC industry classification.	As above
Product Market Fluidity	Cosine similarity between a firm's own words vector and the change in rivals' words vector..	As above
Financial constraint proxies		
KZ index	Kaplan-Zingales index calculated as KZ index = −1.002 × cash flow + 0.283 × Q + 3.139 × Leverage − 39.368 × Dividends − 1.315 × cash holdings	Authors calculations
WW index	Whited Wu index calculated as WW index= 0.93 0.091×Cash Flow 0.062× Dividend Dummy +0.021× Leverage 0.044×Log(Total Assets) +0.102× Industry Sales Growth 0.035× Sales Growth	Authors calculations
SA Index	Size age index is calculated as SA index= -0.737 × Size + 0.043 × $Size^2$ - 0.040 × Age, where size is the log of inflation-adjusted book assets (item 6) and age is the number of years the firm is listed on Compustat.	Authors calculations
Text-based constraint index	The Hoberg and Maksimovic text-based measures of financial constraints are based on firm disclosures in the capitalization and liquidity discussion of firm 10-Ks.	Available at http://faculty.marshall.usc.edu/Gerard-Hoberg/MaxDataSite/index.html

Appendix B: Heckman two-step procedure

VARIABLES	(1) Heckman
Peer R&D Intensity	0.507***
	(9.54)
Size	–0.031***
	(–54.82)
Tobin's Q	0.008***
	(22.86)
Tangibility	–0.059***
	(–10.27)
Leverage	0.028***
	(8.88)
Capex	0.106***
	(6.41)
Institutional Ownership	–0.015***
	(–5.29)
Analyst Coverage	0.003***
	(29.34)
Constant	0.232***
	(9.41)
Select	
Peer R&D Intensity	20.621***
	(126.95)
Constant	–0.807***
	(–97.97)
Observations	54,393
Peer averages of firm characteristics	Yes
Firm-cluster effect	Yes
Year-fixed effect	Yes
Industry fixed effect	Yes
Wald Chi2	12152***