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Auditor specialization in R&D and clients' R&D investment-q sensitivity ☆

Eugenia Y. Lee [a], Wonsuk Ha [b,*], Sunyoung Park [c]

[a] Department of Business Administration, Sejong University, Seoul, South Korea
[b] School of Business Administration, Chung-Ang University, Seoul, South Korea
[c] College of Business Administration, Seoul National University, Seoul, South Korea

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A B S T R A C T

While research and development (R&D) activities contribute to economic growth via technological innovations, they impose significant uncertainty and agency costs. In this study, we examine the governance role of R&D specialist auditors in affecting clients' R&D investment decisions. Using a sample of U.S. firms during 2001–2016, we find that R&D specialist auditors' clients make more efficient investments in the form of a higher R&D investment-q sensitivity. We also find that the reduction in discretionary adjustments of R&D expenses moderates the results. Further, when clients are audited by R&D specialists, their R&D investments are more closely linked to innovative output in subsequent years. Collectively, our results suggest that an auditor's specialized knowledge induces clients to make better economic decisions.

Introduction

Research and development (R&D) activities and the resulting technological innovation are key drivers of economic growth at the firm and economy levels (Kogan et al., 2017). However, the level of R&D investments is much lower than is socially desirable (Jones and Williams, 2000), which is attributable to the high level of uncertainty and information asymmetry involved in R&D activities (Aboody and Lev, 2000; Hall, 2002; Kothari et al., 2002; Li, 2011). Firms seek various internal and external mechanisms that can enhance the efficacy of R&D activities (Amara and Landry, 2005). In this study, we examine the role of external auditors in mitigating the agency costs associated with R&D activities. In particular, we examine how auditors that specialize in R&D activities affect their clients' R&D investment-q sensitivity.

Firms adjust investments in response to investment opportunities. The market-based information on investment opportunities, that is, Tobin's q, complements managers' incomplete information set and helps enhance managerial decision-making (Bond et al., 2012; Tobin, 1969). Empirical studies document that the positive association between investment levels and Tobin's q is even stronger for intangible investments (Peters and Taylor, 2017). Strong corporate governance induces managers to consider market-based information more seriously when making investment decisions (Bhandari and Javakhadze, 2017; Jiang et al., 2011; Kau et al., 2008). Moreover, the relative quality of market-based versus internal infor-

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* Corresponding author at: School of Business Administration, Chung-Ang University, 84, Heukseok-ro, Dongjak-gu, Seoul 06974, South Korea.
E-mail addresses: ylee@sejong.ac.kr (E.Y. Lee), wsha@cau.ac.kr (W. Ha), icecream8491@gmail.com (S. Park).

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mation determines managers' reliance on market-based information in investment decisions (Chen et al., 2007; Edmans et al., 2017; Foucault and Frésard, 2012; Heitzman and Huang, 2019).

Two notable characteristics distinguish R&D investments from other types of investments: riskiness and opaqueness. R&D projects involve high risks since they require considerable trial and error (Thomke, 1998) and generate intangible and highly uncertain output (Hall, 2002; Kothari et al., 2002). Moreover, the absence of traded markets for R&D (Aboody and Lev, 2000) and the expensing of R&D investments make it difficult for external parties to obtain information about the productivity of R&D activities (Kothari et al., 2002). The high risk associated with R&D and the lack of public information about it create significant information asymmetry between the firm and outsiders, leading to large financing costs for R&D investments (Hall, 2002; Li, 2011) and, in turn, underinvestment in R&D (Coles et al., 2006; Li, 2011).

In this context, auditors can benefit their clients' R&D investment process. During the audit process, auditors gain access to in-depth private information about their clients via communication with the managers (Cohen et al., 2007), which enables them to understand clients' proprietary R&D activities and better develop R&D expertise compared to the general public (Aboody and Lev, 2000). Auditors' expertise helps clients not only realize a higher quality of financial reporting (Becker et al., 1998; Reichelt and Wang, 2010) but also make more efficient real decisions (Aobdia, 2015; Bae et al., 2017; Gore et al., 2019; Johnstone et al., 2014; Park and Massel, 2022). Accordingly, clients value auditors' R&D specialization (Godfrey and Hamilton, 2005).

An auditor's R&D specialization is distinct from industry specialization which has been examined in a large body of literature (Bae et al., 2017; Ferguson et al., 2003; Francis et al., 2005; Kwon, 1996; Reichelt and Wang, 2010). Firms in the same industry exhibit significant variations in R&D intensity, which persist over time (Coad, 2019). The size of firm-level R&D expenditure is not directly correlated with firm size because small firms actively engage in R&D (Acs and Audretsch, 1988; Phillips and Zhdanov, 2013; Shefer and Frenkel, 2005). Consequently, an auditor with a larger revenue-based market share in a certain industry does not necessarily have greater expertise in the R&D activities of industry members.

Extending prior evidence on clients' demand for R&D specialist auditors (Godfrey and Hamilton, 2005), we examine how R&D specialist auditors affect clients' R&D investments. Specifically, we predict that R&D specialist auditors would affect clients' R&D investment-q sensitivity through three potential channels. The first is the *monitoring channel*. This channel indicates that R&D specialist auditors can serve as monitors of clients' R&D activities, restricting clients' opportunistic transfer of R&D resources to other purposes and mitigating underinvestment in R&D (Godfrey and Hamilton, 2005). This disciplining effect induces firms to make timelier R&D investments and increase the R&D investment-q sensitivity (Jiang et al., 2011; Kau et al., 2008). The second is the *disclosure quality channel*. This channel suggests that R&D specialist auditors may improve the quality of R&D-related disclosures and reduce information asymmetry between insiders and outsiders, which enhances the informativeness of stock prices and is thereby expected to increase the investment-q sensitivity (Chen et al., 2007; Foucault and Frésard, 2012). The third is the *private information channel*. This channel indicates that R&D specialist auditors can provide the clients with R&D-related knowledge and insights obtained through their network of R&D-intensive clients. The provision of such private information would enrich clients' internal information set, which reduces the clients' reliance on market-based information and lowers the R&D investment-q sensitivity (Edmans et al., 2017; Heitzman and Huang, 2019). Accordingly, we posit that R&D specialist auditors would affect clients' R&D investment-q sensitivity in a direction that depends on how their specialization influences the clients.

Our sample comprises 32,263 U.S. firm-year observations from 2001 to 2016. We measure the auditor's R&D specialization as the auditor's share in R&D activities within a product market (hereafter, "R&D share"), that is, the percentage of R&D expenditure incurred by the auditor's clients within the industry. We define industries according to Hoberg and Phillips's (2016) text-based network industry classification (TNIC) to capture the dynamic nature of a firm's innovative activities.

Empirical analyses reveal that clients' R&D investments become more sensitive to Tobin's q when auditors specialize in R&D activities, which is consistent with the monitoring or disclosure quality channel but not with the private information channel. We perform additional analyses to address the concern that firms with stronger corporate governance or those that attach greater importance to R&D activities may be more likely to hire R&D specialists and, concurrently, make more efficient R&D investments.[1] We perform a difference-in-differences (DiD) analysis centering on an auditor's initial development of R&D expertise. Furthermore, we use propensity score matching (PSM) and entropy balancing approaches to balance the sample characteristics of clients of R&D specialists and non-specialists. The results of all additional analyses are consistent with our main results, which provides further support to our inferences.

We perform cross-sectional analyses to provide an in-depth understanding of the findings. The effect of R&D specialist auditors is more pronounced when their R&D expertise develops from longer-tenured contracts or from clients with more similar products, suggesting that the depth and relevance of R&D expertise create value for clients. In addition, our results are more pronounced in the subsample of firms with lower levels of R&D-based real earnings management (Gunny, 2010; Roychowdhury, 2006), consistent with the auditors' monitoring of discretionary R&D adjustments moderating the main results. By contrast, our results are unrelated to the level of stock price informativeness (Chen et al., 2007; Foucault and Frésard, 2012), suggesting that disclosure quality improvements are unlikely to drive the results.

[1] Note that we consider this issue in the main empirical model by including firm fixed effects to control for systematic differences in firm-specific characteristics including governance; and by excluding the focal firm's R&D expense in the measurement of an auditor's R&D share to capture the auditor's R&D experience orthogonal to the focal firm's R&D activities.

Lastly, we examine the consequences of R&D investments in the presence of R&D specialist auditors. We find that when clients are audited by R&D specialists, their R&D investments are associated with more future innovative output—in terms of the number of patents and patent citations— and with higher performance—in terms of operating cash flows, accounting profits, and stock returns— in subsequent years. Thus, we find that R&D specialist auditors induce the clients to make more productive and effective R&D investments.

This study contributes to the literature in the following ways. First, it adds to the auditing literature on auditors' role in clients' real decisions. Recent studies have examined how auditors affect clients' real decisions, such as operating activities (Aobdia, 2015), real earnings management (Choi et al., 2018a), investments (Bae et al., 2017), and acquisitions (Cai et al., 2016; Dhaliwal et al., 2016). Bae et al.'s (2017) study, which is most relevant to this study, documents that an auditor's industry specialization enhances clients' investment efficiency. We advance the existing research by focusing solely on R&D and reporting how auditors affect R&D investment decisions and output.

Second, this study adds to the literature on auditors' specialization. The literature has long identified the importance of auditors' specialized industry knowledge (Bae et al., 2017; Ferguson et al., 2003; Francis et al., 2005; Kwon, 1996; Reichelt and Wang, 2010). This study further contributes to the literature on auditors' specialization by locating the source of knowledge and examining its effects in terms of R&D activities. In doing so, it extends the scope of auditors' specialization in specific types of transactions, which has so far covered areas such as supply chains (Johnstone et al., 2014), strategic alliances (Gore et al., 2019), and initial public offerings (Park and Massel, 2022). This study extends Godfrey and Hamilton's (2005) study by examining the consequences of hiring an R&D specialist auditor and that of Ha and Park (2021) by generalizing their findings in the Korean market to the U.S. market.

Lastly, we identify one relevant channel through which firms may improve their R&D investment decisions. Despite the importance of R&D activities for promoting economic growth, only a few studies on corporate investments focus on R&D investment (e.g., Li, 2011; Peters and Taylor, 2017). This study highlights the role of auditors in facilitating firms' innovative activities and complements prior studies on the determinants of corporate innovation (e.g., Mukherjee et al., 2017; Thomke, 1998).

This paper proceeds as follows. Section 2 summarizes the related literature and develops the hypothesis. Section 3 describes the research design, and Section 4 presents the empirical results. Section 5 concludes this study.

Literature review and hypothesis development

Investment-q sensitivity and R&D investment

The stock market possesses aggregate information about the firm, and its assessment of firms' investment opportunities is revealed in Tobin's q—the ratio of the firm's market value to replacement costs. Studies have theorized and documented a positive relationship between a firm's investment level and Tobin's q (Abel and Eberly, 2011; Blanchard et al., 1993; Hayashi, 1982; Summers, 1981; Tobin, 1969). Shareholders respond positively to investments only when the investments are aligned with large investment opportunities (Chung et al., 1998).

Although managers possess in-depth information about their firms, they have incentives to consider market-based information about investment opportunities to complement their intra-firm information set when making investment decisions (Bond et al., 2012). This tendency contributes to the positive investment-q sensitivity. Studies report that the investment-q sensitivity varies with the strength of corporate governance and the relative quality of external versus internal information. For example, a strong governance mechanism effectively disciplines managers and increases the investment-q sensitivity, as observed in firms with a lower ownership wedge (Jiang et al., 2011) or high pay-for-performance sensitivity of CEO compensation (Kau et al., 2008). In addition, high-quality market information increases the sensitivity, as observed in firms with high stock price informativeness (Chen et al., 2007; Edmans et al., 2017) or cross-listed firms (Foucault and Frésard, 2012). Similarly, high-quality internal information reduces the investment-q sensitivity (Heitzman and Huang, 2019).

In comparison with capital investments, R&D investments are more likely to be subject to severe underinvestment and agency costs owing to their greater riskiness and opaqueness (Aboody and Lev, 2000; Hall, 2002; Kothari et al., 2002; Thomke, 1998). Despite the distinct characteristics of R&D investments, most prior studies on the investment-q sensitivity focus on capital investments. However, owing to their resultant innovations, R&D investments have gained greater importance over time as drivers of corporate and economic growth (Kogan et al., 2017). This trend necessitates further investigation into the determinants of firms' R&D activities. In this context, we examine how auditors' R&D specialization affects the sensitivity of R&D investments to investment opportunities.

Auditors and investment decisions

Although auditors are not explicitly responsible for monitoring clients' real activities, they affect clients' economic decisions via their monitoring of earnings management, effect on financial reporting quality, and transfer of specialized knowledge. First, auditors are responsible for detecting earnings management, including that through the adjustment of real operations, namely, real earnings management (Roychowdhury, 2006). Reducing R&D investment is an important tool for real earnings management because R&D investment is directly expensed in financial statements (Kothari et al., 2002). Real earnings management increases firm risks, impairing future performance (Filip et al., 2015; Vorst, 2016) and increasing the probability of shareholder litigation against firms and auditors (Ibrahim et al., 2011; Kim and Park, 2014). Moreover, it provides a negative signal about managers' integrity, creating a red flag for auditors about audit risks (Commerford et al., 2019).[2] In effect, high-quality auditors effectively reduce clients' real earnings management (Choi et al., 2018a).

Second, auditors may indirectly affect clients' investment decisions through their effect on financial reporting quality. The primary role of auditors is to ensure clients' financial reporting quality (Che et al., 2020; Francis et al., 1999; Reichelt and Wang, 2010). Higher financial reporting quality reduces information asymmetry between firm insiders and outsiders, thereby contributing to more effective and efficient decision-making by management (Biddle et al., 2009).

Third, auditors are information intermediaries that provide value to their clients by sharing specialized knowledge, which helps clients make better investment decisions. Bae et al. (2017) show that industry specialist auditors enable clients to realize greater capital investment efficiency. Aobdia (2015) demonstrate that clients sharing auditors exhibit more similar operating and investment decisions than do those with different auditors. Cai et al. (2016) and Dhaliwal et al. (2016) find that when the acquirer and target firms share a common auditor, they engage in higher-quality mergers and acquisitions.

Hypothesis development

Auditors have incentives to develop expertise in complex transactions because the high cost of acquiring skills for verifying such transactions creates an entry barrier for others (Cahan et al., 2008; Godfrey and Hamilton, 2005). For example, auditors are known to develop specialization in complex transactions such as those related to supply chains (Johnstone et al., 2014), strategic alliances (Gore et al., 2019), and initial public offerings (Park and Massel, 2022). Similarly, the riskiness and opaqueness of R&D activities create incentives for auditors to develop R&D-related expertise.

Auditors with R&D expertise may affect clients' R&D investment-q sensitivity via three different channels, namely, the monitoring, disclosure quality, and private information channels. First, the monitoring channel predicts that R&D specialist auditors would be able to monitor clients' R&D investments, inducing clients to utilize investment opportunities more effectively, thereby increasing the R&D investment-q sensitivity. R&D specialist auditors effectively monitor the corporate resources spent on R&D activities (Godfrey and Hamilton, 2005). Their monitoring can restrict managers' appropriation of related assets and promote efficient investment (Bushman and Smith, 2001; Kau et al., 2008). In terms of the investment-q sensitivity, more disciplined managers are more likely to incorporate market-based information in making investment decisions (Bhandari and Javakhadze, 2017; Edmans et al., 2017; Kau et al., 2008). Thus, R&D specialist auditors' effective monitoring of clients' R&D activities would increase the R&D investment-q sensitivity.

Second, the disclosure quality channel suggests that R&D specialist auditors would improve the quality of R&D-related disclosure, enhancing the informativeness of stock prices and increasing the R&D investment-q sensitivity.[3] The opaqueness of R&D investment creates information asymmetry between a firm's insiders and outsiders (Hall, 2002; Li, 2011). R&D specialist auditors can help their clients make high-quality disclosures about R&D activities, which would reduce information asymmetry and enhance stock price informativeness. In this case, managers would be more inclined to learn about their investment opportunities from the stock market (Chen et al., 2007; Edmans et al., 2017; Foucault and Frésard, 2012), leading to an increase in the R&D investment-q sensitivity.

Third, the private information channel indicates that R&D specialist auditors would enrich the internal information of clients and decrease the R&D investment-q sensitivity. In conducting audits, auditors communicate with their clients' top management and obtain proprietary information (Cohen et al., 2007). This information acquisition deepens their knowledge of and gives them insights into R&D activities conducted in relevant fields, which can be transferred privately to other clients.[4] In this case, auditors would enrich clients' internal information set related to R&D, inducing clients to rely less on market-based information (Edmans et al., 2017; Heitzman and Huang, 2019), which would reduce the R&D investment-q sensitivity.

In summary, the monitoring and disclosure quality channels predict that clients of R&D specialist auditors will exhibit higher R&D investment-q sensitivity, whereas the private information channel predicts the opposite. Based on the three different predictions, we present the following null hypothesis.

Hypothesis: An auditor's specialization in R&D is not associated with clients' R&D investment-q sensitivity.

Research design

R&D specialist auditors

An auditor's share in R&D activities within an industry is used as a base for measuring the depth of the auditor's R&D specialization. Industries are defined according to Hoberg and Phillips' (2016) TNIC scheme. The TNIC identifies, for each

[2] In response to real earnings management, auditors conduct stricter audit procedures (Commerford et al., 2016), charge higher audit fees (Choi et al., 2018b; Greiner et al., 2017), and resign from audit engagements (Kim and Park, 2014).

[3] We thank an anonymous reviewer for suggesting this channel.

[4] This knowledge transfer does not require auditors to directly leak clients' proprietary information to competitors; auditors' insights and knowledge about general industry trends and best practices in R&D activities can benefit other clients.

focal firm, peers whose products are similar to those of the focal firm based on the pairwise similarity of product descriptions in the SEC 10-K filings, relaxing the assumption that all industry members face homogenous competition levels. Moreover, as the TNIC is measured on an annual basis, it allows us to capture the time-varying, dynamic nature of the competitive environment. For each firm's TNIC industry in year *t*, we calculate the auditor's R&D share in the product market (*RSA_SHARE*) as the sum of R&D expenses spent by TNIC peers audited by the incumbent auditor in year $t-1$ scaled by the sum of R&D expenses of all firms in the TNIC industry. *RSA_SHARE* captures the incumbent auditor's prior-year experience of auditing the R&D activities of the client's current TNIC peers.[5] Although our measurement is similar to that of Godfrey and Hamilton (2005), we additionally require that R&D expenditure be incurred by clients in the TNIC industry.[6] We add this restriction because the size and characteristics of R&D investments differ across sectors (Malerba, 2005), and an auditor's R&D specialization would be effective when developed in an area most relevant to the client's product market.

For the empirical analyses, we construct two test variables based on *RSA_SHARE*. *RSA1* is an indicator variable that equals one if *RSA_SHARE* exceeds 0.2, and 0 otherwise.[7] *RSA2* is defined as the decile rank of *RSA_SHARE* that reduces the effect of outliers in the continuous variable, scaled to range between zero and one. Specifically, we assign firms with zero values of *RSA_SHARE* to the bottom decile and the remaining firms to the other deciles.

Investment-q sensitivity

We follow prior studies in setting the empirical model for the investment-q sensitivity (e.g., Chen et al., 2007; Jiang et al., 2011). Specifically, we estimate the following equation with an ordinary least squares regression.

$$RDX_{it} = \beta_0 + \beta_1 TOBINQ_{i,t-1} + \Sigma\beta Controls_{it} + Year\ FE + Firm\ FE + \varepsilon_{it} \quad (1)$$

For firm *i* and year *t*, the dependent variable *RDX* is the R&D intensity measured by R&D expenditure divided by the firm's beginning-of-year total assets. Tobin's q (*TOBINQ*) is calculated as the market value of equity plus the book value of assets less the book value of equity scaled by total assets. *TOBINQ* is measured as of the beginning of the year and used as a proxy for the market valuation of the firm's investment opportunities. The R&D investment-q sensitivity is represented by β_1, which is expected to be positive (Peters and Taylor, 2017).

We control for firm and auditor characteristics that are known to affect the investment-q sensitivity. Specifically, we include the inverse of lagged total assets (*INVTA_L1*) and market capitalization (*SIZE*) to control for the scale effect of investments and firm size; operating cash flows (*CF*) to control for financial constraints; and cumulative abnormal returns (*CAR*) to control for overvalued firms' tendency to increase investment. We also include auditor-level control variables, such as Big 4 auditors (*BIG4*), industry specialist auditors (*ISA*), and the auditor's tenure (*TENURE*). The detailed definitions of the variables are provided in the Appendix. All continuous variables are winsorized at the top and bottom one percent. We also include year and firm fixed effects to prevent our results from being affected by time trends and across-firm variations in R&D investments. We assess statistical significance based on standard errors clustered by firm (Petersen, 2009).

Empirical model

To test the hypothesis, we extend Equation (1) as follows.

$$RDX_{it} = \beta_0 + \beta_1 TOBINQ_{i,t-1} + \beta_2 TOBINQ_{i,t-1} \times RSA_{it} + \beta_3 RSA_{it} + \Sigma\beta Controls_{it} + Year\,FE + Firm\,FE + \varepsilon_{it} \quad (2)$$

For firm *i* and year *t*, all variables are as defined in Equation (1). The variable of interest is *TOBINQ*×*RSA*, where *RSA* is either *RSA1* or *RSA2*, as defined above. The coefficient β_2 represents how an R&D specialist auditor affects the sensitivity of R&D investments to Tobin's q. β_2 is expected to be positive if the monitoring or disclosure quality channel prevails and negative if the private information channel dominates. We also control for interactions of *TOBINQ* with other auditor-related variables, that is, *BIG4*, *ISA*, and *TENURE* to ensure that our results are distinct from those attributable to other auditor characteristics.

Sample and data

We obtain information on auditors' identities from Audit Analytics, clients' financial statements from Compustat, and stock prices from CRSP. We retrieve data on each firm's TNIC industry from Hoberg and Phillips' (2016) website.[8]

[5] We note three empirical considerations regarding our measure of auditors' R&D specialization. First, we exclude the focal firm's R&D expenses to eliminate any mechanical association between the measure and the focal firm's R&D expenses. Second, we use the auditor's R&D-related experience in the year $t-1$ to capture the experience accumulated before the current year's audit. Third, the measure is a time-varying, firm-level measure since each firm-year has a different set of TNIC peers.

[6] By contrast, Godfrey and Hamilton (2005) measure an auditor's R&D specialization as the percentage of R&D expenditure incurred by the auditor's clients regardless of the industry membership.

[7] Our main results remain qualitatively similar when we use an alternative threshold of 0.1 or 0.3 (untabulated).

[8] The data are available at: https://hobergphillips.tuck.dartmouth.edu/.

The sample period spans 2001–2016. To ensure the comparability of financial information, we exclude firms in financial industries (SIC codes 6000–6999) from the sample. To eliminate the effect of outliers, we exclude firms whose total assets or sales are less than US$ 1 million. We require the firms to have at least three TNIC peers to reduce noise in the measure of auditors' specialization. We also require each TNIC industry to have positive R&D expenses because industries without any R&D expenses are irrelevant to our study. Finally, after requiring firm-years to have sufficient data for calculating all the variables, we obtain a final sample of 5,098 unique firms and 32,263 firm-years.

Descriptive statistics

Panel A of Table 1 presents the descriptive statistics of the variables used in the main analysis. In our sample, an average firm engages in R&D investments (*RDX*) that amount to 7.5% of lagged total assets. Auditors, on average, have experience in auditing 20.7% of the R&D activities of clients' TNIC peers (*RSA_SHARE*), and 37.3% of firm-years are identified as being audited by an R&D specialist auditor (*RSA1*). The market value of a firm is, on average, 2.170 times its book value (*TOBINQ*). The average firm realizes operating cash flows of 8.9% of lagged total assets (*CF*) and exhibits market-adjusted buy-and-hold returns of 6.9% during the fiscal year (*CAR*). Overall, 80.4% of observations are audited by Big 4 auditors (*BIG4*), and 28.0% by industry specialist auditors (*ISA*). The average tenure of an auditor is 6.218 years (*TENURE*).

Panel B of Table 1 presents the Pearson correlations among the variables. Firms that invest more in R&D activities (*RDX*) are more likely to be audited by an R&D specialist auditor (*RSA1* and *RSA2*), have higher market valuations (*TOBINQ*), be smaller (*SIZE*), and realize smaller operating cash flows (*CF*). Additionally, they are more likely to be audited by a non-Big 4 auditor (*BIG4*), an industry specialist auditor (*ISA*), and an auditor with a shorter tenure (*TENURE*). R&D specialist auditors (*RSA1* and *RSA2*) are more likely to be Big 4 (*BIG4*) and industry specialist auditors (*ISA*). However, the correlations are low enough to show that R&D specialization is empirically distinguishable from auditors' size and industry specialization.[9]

Empirical results

R&D specialist auditors and the R&D investment-q sensitivity

We test the hypothesis by estimating Equation (2) using ordinary least squares regression. Table 2 presents the results. In Columns (1) and (2), the test variables are *RSA1* and *RSA2*, respectively. In Column (1), the coefficient on *TOBINQ* is significantly positive (coefficient = 0.010, *t*-statistic = 11.08), which is consistent with managers incorporating market-based information in making R&D investment decisions (Barro, 1990; Chen et al., 2007; Peters and Taylor, 2017). The coefficient on *TOBINQ*×*RSA* is significantly positive (coefficient = 0.003, *t*-statistic = 3.33), suggesting that clients of an R&D specialist auditor exhibit a higher sensitivity of R&D investment to Tobin's q.[10] In terms of economic significance, the R&D investment-q sensitivity is higher by 30% (=0.003 / 0.010) when firms' auditors are R&D specialists compared to when they are not. The results with *RSA2* in Column (2) are also consistent with the results in Column (1).[11] In Columns (3) and (4), we additionally control for the effect of auditor characteristics such as auditor size, industry specialization, or auditor–client relationship. We continue to find a significantly positive coefficient on *TOBINQ*×*RSA*, suggesting that the effect of R&D specialist auditors on the R&D investment-q sensitivity is unlikely to be attributable to other auditor characteristics.[12] Overall, we find that firms more actively incorporate market-based information in their R&D investment decisions when audited by R&D specialist auditors, consistent with the monitoring or disclosure quality channel but not with the private information channel.

We corroborate our findings with a DiD analysis on switches from a non-specialist to an R&D specialist auditor.[13] To control for the effect of auditor switches in general, we only compare among firms that switch their auditors in year t: the treatment sample comprises firms that switch their auditors from a non-specialist to an R&D specialist (*TREAT* = 1), and the control sample comprises firms that switch their auditors from a non-specialist to another non-specialist (*TREAT* = 0). The event year t is identified as the year when the client switches its auditor. We match each treatment firm to a control firm with the closest Tobin's q within the same year and market capitalization decile as of year *t*. We impose a restriction that firms retain the same

[9] We further confirm that the variance inflation factor of our test variable is well below 10 in all the regressions, which suggests that our results are not vulnerable to multicollinearity (Kennedy, 2008).

[10] We notice a significantly negative coefficient on *RSA*. As this coefficient represents the effect of *RSA* for firms with zero values of Tobin's q (*TOBINQ* = 0) and such firms are nonexistent in reality, we do not provide an economic interpretation of the negative coefficient.

[11] When we use abnormal R&D investments as an alternative proxy for investment efficiency (e.g., Bae et al., 2017; Biddle et al., 2009; McNichols and Stubben, 2008), we do not find any significant association between R&D specialist auditors and their clients' abnormal R&D investments. We attribute the results to the theoretical differences underlying the two proxies: The investment-q sensitivity model assumes that a higher sensitivity (*larger* slope coefficient) to investment opportunities represents greater efficiency, whereas the abnormal investment model assumes that the optimal slope coefficient is *constant* across different firms and interprets a smaller deviation from the benchmark level as representing greater efficiency. We further confirm that our main results with the investment-q sensitivity are robust in both underinvestment and overinvestment subsamples.

[12] To ensure that our results are distinct from the effect of industry specialist auditors, we divide the sample into two subsamples based on *ISA*. In untabulated tests, we find that the association between R&D specialist auditors and their clients' R&D investment-q sensitivity is consistently observed in both industry specialist (*ISA* = 1) and non-specialist (*ISA* = 0) subsamples. Therefore, our results are distinct from and incremental to the effect of industry specialization.

[13] Although these auditor switches are pronounced events that induce changes in auditors' specialization, they may signal firms' intentions to actively seek changes in governance structure. We address this issue by performing a DiD analysis for the sample of constant client–auditor pairs in Section "Changes in auditors' R&D specialization".

Table 1
Summary statistics.

Panel A. Descriptive statistics (N = 32,263)

Variable	Mean	Std. Dev.	P10	P25	P50	P75	P90
RDX	0.075	0.123	0.000	0.000	0.018	0.105	0.214
RSA_SHARE	0.207	0.271	0.000	0.000	0.075	0.338	0.623
RSA1	0.373	0.483	0.000	0.000	0.000	1.000	1.000
RSA2	0.373	0.351	0.000	0.000	0.333	0.667	0.889
TOBINQ	2.170	1.655	0.923	1.155	1.611	2.518	4.077
INVTA_L1	0.010	0.021	0.000	0.001	0.002	0.009	0.028
SIZE	6.296	2.029	3.613	4.877	6.290	7.670	8.971
CF	0.089	0.181	−0.112	0.034	0.103	0.180	0.273
CAR	0.069	0.601	−0.514	−0.285	−0.032	0.255	0.684
BIG4	0.804	0.397	0.000	1.000	1.000	1.000	1.000
ISA	0.280	0.449	0.000	0.000	0.000	1.000	1.000
TENURE	6.218	4.091	2.000	3.000	5.000	9.000	13.000

Panel B. Correlations

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
[1]	*RDX*	1.00									
[2]	*RSA1*	**0.17**	1.00								
[3]	*RSA2*	**0.16**	**0.89**	1.00							
[4]	*TOBINQ*	**0.44**	**0.08**	**0.09**	1.00						
[5]	*INVTA_L1*	**0.34**	**−0.13**	**−0.15**	**0.22**	1.00					
[6]	*SIZE*	**−0.19**	**0.15**	**0.17**	**0.10**	**−0.56**	1.00				
[7]	*CF*	**−0.01**	**0.06**	**0.07**	**0.10**	**−0.24**	**0.33**	1.00			
[8]	*CAR*	0.00	**0.01**	0.01	**−0.12**	**0.05**	**0.11**	**0.21**	1.00		
[9]	*BIG4*	**−0.02**	**0.36**	**0.44**	−0.01	**−0.40**	**0.42**	**0.14**	**0.03**	1.00	
[10]	*ISA*	**0.02**	**0.17**	**0.18**	0.01	**−0.14**	**0.23**	**0.05**	0.01	**0.25**	1.00
[11]	*TENURE*	**−0.05**	**0.09**	**0.09**	**−0.04**	**−0.21**	**0.35**	**0.12**	**−0.04**	**0.24**	**0.12**

This table provides the summary statistics of the variables used in the main analysis. Panel A presents the descriptive statistics for the variables. Panel B presents the Pearson correlations between variables. The figures in bold represent statistical significance at the 5% level.

auditors in years t–2 and t–1 (*POST* = 0) and in years t and t+1 (*POST* = 1). Finally, we obtain 280 firm-year observations for years t–2 to t+1.[14] Fig. 1 illustrates the DiD research design.

Columns (1) and (2) of Table 3 present the results of the DiD analysis without and with controls for auditor characteristics, respectively. We find that the coefficient on *TOBINQ*×*TREAT*×*POST* is significantly positive in both columns, suggesting that the client's R&D investment-q sensitivity increases when the client switches its auditor from a non-specialist to an R&D specialist. Thus, the DiD results lend further support to our inference that clients of R&D specialist auditors rely more on market-based information in making R&D investments.

Next, we examine the capital investment-q sensitivity of R&D specialist auditors' clients. The riskiness and opaqueness of R&D and capital investments differ significantly (Aboody and Lev, 2000; Hall, 2002; Kothari et al., 2002). Accordingly, we expect that the auditors' specialization in R&D activities would be less relevant to clients' capital investment decisions, and, therefore, less likely to affect clients' capital investment-q sensitivity. To examine this issue, we replace the dependent variable of Equation (2) with capital investment intensity, defined as capital expenditure scaled by lagged net plant, property, and equipment. In untabulated analysis, we find that the coefficient on *TOBINQ* is significantly positive, but that on *TOBINQ*×*RSA* is *negative* and insignificant in three out of four specifications. These results suggest that the auditors' R&D specialization is unlikely to be relevant for firms' capital investment decisions and is thus particularly beneficial for firms' R&D activities.

Controlling for the effect of client characteristics

Changes in auditors' R&D specialization

Our results may potentially be driven by unobserved client characteristics that jointly determine the client's investments and auditor-hiring decisions; for example, firms with stronger corporate governance or those that consider R&D activities important may decide to hire R&D specialist auditors and, concurrently, make more efficient investment decisions. To address this concern, we conduct two additional analyses: DiD and sample balancing.[15]

[14] As we start from a limited number of auditor-switching cases, we obtain a small matched sample for this DiD analysis. Therefore, we caution readers that the results of this analysis should be considered complementary to our main findings for the full sample.

[15] In our main analysis, we attempt to address this concern by including firm-fixed effects that control for unobserved but persistent firm-level differences in corporate governance. We also exclude the focal firm's R&D expenditure when measuring auditors' specialization (*RSA*) to ensure that the auditors' specialization is orthogonal to the focal firm's R&D activities. We thank the editor and an anonymous reviewer for suggesting additional analyses to further address the concern.

Table 2
Auditors' R&D specialization and the R&D investment-q sensitivity.

Dep. Variable =	*RDX*			
RSA =	*RSA1* (1)	*RSA2* (2)	*RSA1* (3)	*RSA2* (4)
TOBINQ	0.010***	0.010***	0.010***	0.009***
	(11.08)	(9.16)	(6.30)	(6.02)
TOBINQ×RSA	0.003***	0.004***	0.004***	0.005***
	(3.33)	(2.63)	(3.54)	(3.30)
TOBINQ×BIG4			−0.002	−0.002
			(−1.05)	(−1.34)
TOBINQ×ISA			0.000	0.001
			(0.37)	(0.50)
TOBINQ×TENURE			0.000	0.000*
			(1.55)	(1.74)
RSA	−0.007***	−0.008***	−0.007***	−0.009***
	(−3.55)	(−2.79)	(−3.86)	(−3.59)
INVTA_L1	1.403***	1.404***	1.406***	1.407***
	(11.16)	(11.13)	(11.19)	(11.20)
SIZE	−0.009***	−0.009***	−0.009***	−0.009***
	(−7.86)	(−7.85)	(−8.04)	(−8.03)
CF	0.040***	0.040***	0.040***	0.040***
	(6.40)	(6.38)	(6.41)	(6.37)
CAR	0.009***	0.009***	0.009***	0.009***
	(9.08)	(9.09)	(9.07)	(9.08)
BIG4			0.004	0.005
			(1.04)	(1.19)
ISA			−0.001	−0.002
			(−0.55)	(−0.70)
TENURE			−0.001*	−0.001**
			(−1.93)	(−2.07)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	32,263	32,263	32,263	32,263
Adjusted R^2	0.843	0.843	0.843	0.843

This table presents the results of examining the effect of R&D specialist auditors on the R&D investment-q sensitivity. The definitions of all variables are provided in the Appendix. The figures in parentheses represent *t*-statistics calculated based on standard errors clustered by firm. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively..

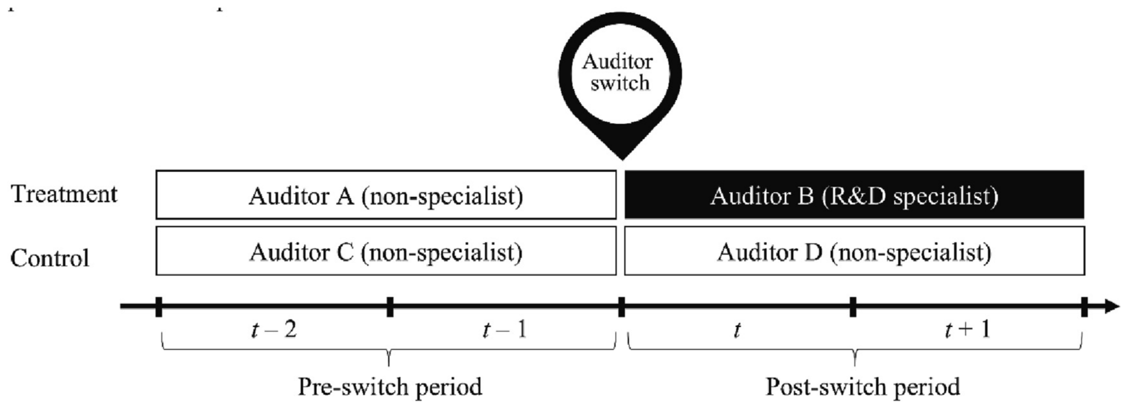

Fig. 1. Auditor switches from a non-specialist to an R&D specialist auditor: Research design.This figure illustrates the research design of a difference-in-differences analysis on auditor switches from a non-specialist to an R&D specialist auditor.

We first conduct a DiD analysis on the changes in auditors' specialization for a sample of client firms retaining the same auditors.[16] To remove the confounding effect of firm characteristics associated with the selection of specialist auditors, we focus

[16] As this analysis employs a sample of client firms that do not switch their auditors over the sample period and our proxy for auditors' specialization is determined by auditors' clients excluding the focal client, we capture the effect of auditor's R&D specialization that is unlikely to be determined by the focal client. Nevertheless, to the extent that other unobservable market factors simultaneously affect both auditors' specialization and the focal client's investments, this analysis may not fully eliminate endogeneity concerns.

Table 3
Auditor switches from a non-specialist to an R&D specialist auditor: Difference-in-differences analysis.

Dep. Variable =	*RDX*	
	(1)	(2)
TOBINQ	−0.006	−0.013
	(−0.91)	(−1.39)
TOBINQ×*TREAT*	0.004	−0.002
	(0.39)	(−0.21)
TOBINQ×*POST*	−0.014	−0.008
	(−1.61)	(−0.82)
TOBINQ×*TREAT*×*POST*	0.020*	0.031***
	(1.85)	(2.85)
TOBINQ×*BIG4*		−0.006
		(−0.90)
TOBINQ×*ISA*		0.004
		(0.39)
TOBINQ×*TENURE*		0.003**
		(2.19)
TREAT×*POST*	−0.034*	−0.052***
	(−1.76)	(−2.70)
POST	−0.006	−0.013
	(−0.91)	(−1.39)
Controls	Yes	Yes
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	280	280
Adjusted R-squared	0.848	0.856

This table presents the results of a difference-in-differences analysis on switches from a non-specialist to an R&D specialist auditor. The sample consists of firms that switch auditors as of year *t*. *TREAT* is an indicator that equals 1 for firms that switch from a non-specialist to an R&D specialist auditor and 0 for firms that switch from a non-specialist to another non-specialist auditor. *POST* is an indicator that equals 1 for the post-switch period (years *t* and *t*+1) and 0 for the pre-switch period (years *t*−2 and *t*−1). The definitions of the other variables are provided in the Appendix. The figures in parentheses represent *t*-statistics calculated based on standard errors clustered by firm. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

on a sample of firms that are audited by a non-specialist auditor in year *t*–2 and retain that auditor for five consecutive years, that is, from years *t*–2 to *t*+2. Among such firms, we identify treatment firms (*TREAT* = 1) as the firms whose non-specialist auditors in years *t*–2 and *t*–1 (the pre-transition period, *POST* = 0) become R&D specialists in years *t*+1 and *t*+2 (the post-transition period, *POST* = 1). To ensure that auditors have developed a significant level of R&D expertise over time (Gaver and Utke, 2019), we require their R&D share to increase by more than one standard deviation (25 percentage points) from years *t*–1 to *t*+1, allowing for a one-year transition period (year *t*). The control sample (*TREAT* = 0) comprises firms whose auditors remain non-specialists throughout years *t*–2 to *t*+2. We match control firms to treatment firms with the closest TOBINQ within the same year and market capitalization decile. The matching process yields 141 matched pairs of treatment and control firms from which we secure 1,128 firm-year observations for years *t*–2, *t*–1, *t*+1, and *t*+2. Fig. 2 illustrates the DiD research design.

The results of the DiD analysis are provided in Table 4. We find that the coefficient on *TOBINQ*×*TREAT*×*POST* is significantly positive in both columns without and with controls for other auditor characteristics. These results suggest that the R&D investment-q sensitivity increases after the firms' incumbent auditors develop R&D expertise, supporting our inference on the beneficial role of R&D specialist auditors.

Sample balancing

We implement a PSM analysis to balance the covariates between treatment and control samples (Shipman et al., 2017), the results of which are not tabulated for brevity. In the first stage estimation, we estimate the propensity of firms to hire an R&D specialist auditor (*RSA1* = 1) using a logit regression after controlling for all covariates in Equation (2). Using the estimated results, we match firm-years with R&D specialist auditors (*RSA1* = 1) to those without R&D specialist auditors (*RSA1* = 0) having the nearest propensity score within the caliper distance of 0.01.[17] Consequently, we secure a matched sample of 22,400 firm-years, with an equal number of firm-years audited by R&D specialist and non-specialist auditors. We find that all covariates are reasonably balanced, and our results continue to hold in the propensity score-matched sample.

Alternatively, we use an entropy-balancing approach, which re-weights observations such that the first, second, and third moments of the covariates are balanced for firms with and without R&D specialist auditors. This balancing scheme retains all observations and alleviates the concern that the PSM sample is not properly representative of the original sample (Hainmueller, 2012). The (untabulated) results with entropy balancing are consistent with the main results. Thus, we conclude that our findings are unlikely to be driven by differences between the characteristics of firms that hire R&D specialist auditors and those that do not.

[17] Our results are robust when a stricter caliper distance of 0.005 or a laxer distance of 0.03 is imposed (untabulated).

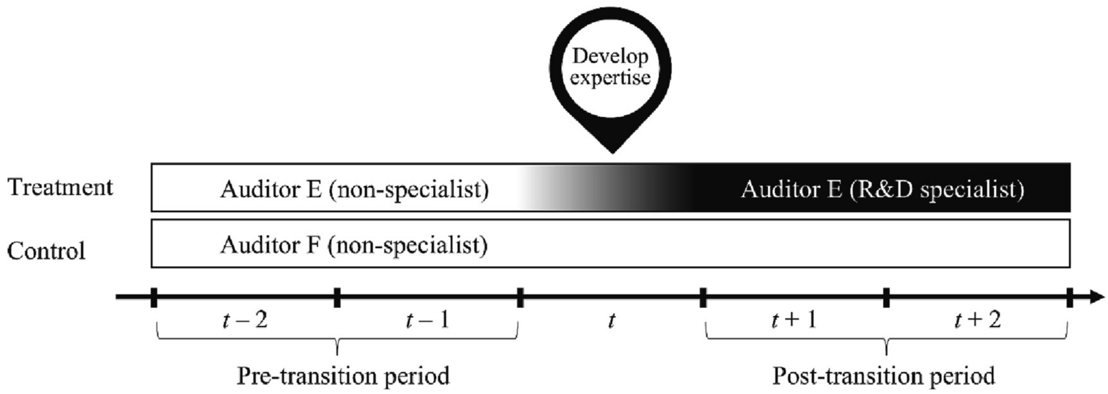

Fig. 2. Changes in R&D specialization: Research design.This figure illustrates the research design of a difference-in-differences analysis on changes in an auditor's status as an R&D specialist.

Table 4
Changes in R&D specialization: Difference-in-differences analysis.

Dep. Variable =	*RDX*	
	(1)	(2)
TOBINQ	0.000	−0.003
	(0.06)	(−1.13)
TOBINQ×TREAT	−0.001	−0.005
	(−0.40)	(−1.51)
TOBINQ×POST	−0.001	−0.002
	(−0.42)	(−0.84)
TOBINQ×TREAT×POST	0.007**	0.008**
	(2.02)	(2.15)
TOBINQ×BIG4		0.006
		(1.52)
TOBINQ×ISA		0.001
		(0.54)
TOBINQ×TENURE		0.000
		(0.56)
TREAT×POST	−0.010*	−0.011**
	(−1.93)	(−2.06)
POST	−0.001	0.001
	(−0.38)	(0.25)
Controls	Yes	Yes
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	1,128	1,128
Adjusted R-squared	0.942	0.942

This table presents the results of a difference-in-differences analysis on changes in the investment-q sensitivity for clients of auditors who newly develop R&D expertise. The sample consists of firms that retain the same auditor for years $t-2$ to $t+2$. *TREAT* is an indicator variable that equals 1 for clients of auditors who are classified as non-specialists before year *t* and as R&D specialists after year *t*, with *RSA_SHARE* increasing more than the standard deviation from years $t-1$ to $t+1$; and 0 for clients of auditors classified as non-specialists throughout years $t-2$ to $t+2$. *POST* is an indicator variable that equals 1 for the post-transition period (years $t+1$ and $t+2$), and 0 for the pre-transition period (years $t-2$ and $t-1$). The definitions of the other variables are provided in the Appendix. The figures in parentheses represent *t*-statistics calculated based on standard errors clustered by firm. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Cross-sectional analyses

Depth and relevance of auditors' R&D specialization

We next test the variation in the effect of auditors' R&D specialization depending on the source of specialization. First, we expect auditors' specialization would be more beneficial to the client if founded upon a longer experience of auditing firms engaged in R&D (Gaver and Utke, 2019; Geiger and Raghunandan, 2002; Ghosh and Moon, 2005). To test this effect, we decompose *RSA* into *RSA_LONGTEN* and *RSA_SHORTTEN*, representing auditors' R&D specialization from clients with long (more than two years) and short (less than or equal to two years) tenures, respectively. Columns (1) and (2) of Panel A in Table 5 present the results. In both columns, the coefficient on *TOBINQ×RSA_LONGTEN* is significantly positive and larger than that on *TOBINQ*×*RSA_SHORTTEN*, which suggests that the benefits of R&D specialization are more pronounced when the auditor's R&D expertise develops from longer-tenured clients.

We further predict that auditors' R&D specialization would be more relevant in shaping clients' innovative activities if developed from clients with more similar products (Chen et al., 2017; Grabowski and Baxter, 1973; Malerba, 2005). To test this prediction, we decompose *RSA* into *RSA_SIMHIGH* and *RSA_SIMLOW*, where *RSA_SIMHIGH* [*RSA_SIMLOW*] is the auditors' specialization developed from clients whose product similarity score with respect to the focal firm (Hoberg and Phillips, 2010) is above [below] the sample median. Columns (3) and (4) of Panel A in Table 5 present the results. In both columns, the coefficient on *TOBINQ*×*RSA_SIMHIGH* is significantly positive, that on *TOBINQ*×*RSA_SIMLOW* is statistically insignificant, and the former is significantly larger than the latter. These results suggest that an auditor's R&D specialization is more relevant to the clients' decision-making when the auditor accumulates R&D experience from clients with more similar products.

R&D-based real earnings management

In developing the hypothesis, we have discussed three potential channels through which R&D specialist auditors may affect the R&D investment-q sensitivity. Our main results rule out the private information channel. This section provides further evidence on the monitoring and disclosure quality channels.

Regarding the monitoring channel, we examine the moderating effect of R&D-based real earnings management. Effective monitoring of R&D activities reduces firms' discretionary adjustments to R&D expenditures for real earnings management (Osma, 2008), which would, in turn, increase the efficiency of R&D investment decisions. Thus, we examine whether our results are more pronounced when firms exhibit lower R&D-based real earnings management, that is, when firms' opportunistic adjustment of R&D investment is effectively constrained.[18]

We measure real earnings management through discretionary adjustments of R&D expenses (*REM_RD*) as the residual from Equation (3), estimated for each industry-year with at least 15 observations following Gunny (2010), multiplied by (−1).

$$RDX_{i,t}/TA_{i,t-1} = \beta_0 + \beta_1\left(1/TA_{i,t-1}\right) + \beta_2 SIZE_{i,t} + \beta_3 TOBINQ_{i,t} + \beta_4 CF_{i,t}/TA_{i,t-1} + \beta_5 RDX_{i,t-1}/TA_{i,t-1} + \varepsilon_{it} \quad (3)$$

For firm *i* and year *t*, *TA* denotes total assets, and the other variables are as defined previously. We create subsamples partitioned by the 30th and 70th percentile values of *REM_RD*.

Panel B of Table 5 presents the results of estimating Equation (2) for each subsample. As expected, the coefficient on *TOBINQ*×*RSA* is significantly positive for subsamples of low or medium levels of *REM_RD* in Columns (1), (2), (4), and (5) but insignificant for the subsample of high levels of *REM_RD* in Columns (3) and (6); its magnitude monotonically increases from the high *REM_RD* subsample to the low *REM_RD* subsample. This result suggests that the effect of R&D specialist auditors on the R&D investment-q sensitivity is more pronounced when they effectively restrict managers' discretionary reduction of R&D investment, which substantiates the monitoring channel.

Stock price informativeness

Regarding the disclosure quality channel, we examine the moderating effect of stock price informativeness. A high-quality R&D-related disclosure is expected to lower information asymmetry associated with R&D activities and improve stock price informativeness (Gul et al., 2010; Haggard et al., 2008; Jin and Myers, 2006; Zhang et al., 2021), which may result in a higher R&D investment-q sensitivity. Thus, if the disclosure quality channel is valid, we expect our main results to be more pronounced for firms with more informative stock prices.[19]

We measure stock price informativeness, *SPI*, as the logarithmic transformation of the R^2 of the following equation (Morck et al., 2000).

$$RET_{i,w} = \beta_0 + \beta_1 RET_{m,w} + \beta_2 RET_{m,w-1} + \beta_3 RET_{m,w+1} + \beta_4 RET_{j,w} + \beta_5 RET_{j,w-1} + \beta_6 RET_{j,w+1} + \varepsilon_{it} \quad (4)$$

For firm *i*, market *m*, industry *j*, and week *w*, *RET* is the weekly raw return. *SPI* is calculated as $\ln\left\{\left(1 - R^2\right)/R^2\right\}$, such that a higher value of *SPI* indicates greater stock price informativeness. We create subsamples partitioned by the 30th and 70th percentile values of *SPI*.

Panel C of Table 5 presents the results of estimating Equation (2) for each subsample. In Columns (1) to (3), using *RSA1*, we find that the coefficient on *TOBINQ*×*RSA* is significantly positive and increases gradually from the low *SPI* subsample to the high *SPI* subsample. However, when using *RSA2* in Columns (4) to (6), we find that the coefficient on *TOBINQ*×*RSA* is insignificant in the high *SPI* subsample.[20] These results indicate that the effect of R&D specialist auditors does not systematically depend on the level of stock price informativeness and are thus inconsistent with the disclosure quality channel. Collectively,

[18] Alternatively, we test the effect of R&D specialist auditors on the level of R&D-based real earnings management and find that specialist auditors reduce the level of R&D-based real earnings management. This result is consistent with the monitoring channel.

[19] Alternatively, we test the effect of R&D specialist auditors on the level of stock price informativeness and find that clients' stock price informativeness is unaffected by auditors' R&D specialization. This result is inconsistent with the disclosure quality channel.

[20] We find that our main results remain robust and are not significantly different across subsamples partitioned based on alternative proxies for information asymmetry, such as Amihud's (2002) illiquidity measure, bid-ask spreads, and absolute discretionary accruals.

Table 5
Cross-sectional analyses.

Panel A. Depth and relevance of auditors' R&D specialization.

Dep. Variable =	*RDX*			
RSA =	*RSA1*	*RSA2*	*RSA1*	*RSA2*
	(1)	(2)	(3)	(4)
TOBINQ	0.010***	0.009***	0.010***	0.009***
	(6.39)	(5.73)	(6.29)	(5.70)
TOBINQ×RSA_LONGTEN	0.005***	0.007***		
	(4.13)	(4.24)		
TOBINQ×RSA_SHORTTEN	−0.000	0.003**		
	(−0.28)	(2.48)		
TOBINQ×RSA_SIMHIGH			0.007***	0.013***
			(2.89)	(6.98)
TOBINQ×RSA_SIMLOW			0.000	0.002
			(0.42)	(1.33)
TOBINQ×BIG4	−0.002	−0.004**	−0.001	−0.005***
	(−1.00)	(−2.20)	(−0.44)	(−2.79)
TOBINQ×ISA	0.000	0.000	0.001	0.000
	(0.27)	(0.36)	(0.42)	(0.03)
TOBINQ×TENURE	0.000	0.000*	0.000*	0.000*
	(1.07)	(1.68)	(1.69)	(1.74)
RSA_LONGTEN	−0.010***	−0.012***		
	(−4.51)	(−4.36)		
RSA_SHORTTEN	−0.001	−0.007***		
	(−0.48)	(−2.95)		
RSA_SIMHIGH			−0.014***	−0.021***
			(−2.73)	(−5.67)
RSA_SIMLOW			−0.002	−0.004
			(−0.95)	(−1.48)
Test statistics				
TOBINQ×RSA_LONGTEN −TOBINQ×RSA_SHORTTEN	0.005***	0.004***		
[*F*-statistics]	[8.42]	[4.36]		
TOBINQ×RSA_SIMHIGH −TOBINQ×RSA_SIMLOW			0.007***	0.012***
[*F*-statistics]			[6.12]	[17.66]
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	32,263	32,263	32,263	32,263
Adjusted R^2	0.844	0.844	0.843	0.845

Panel B. Moderating effect of R&D-based real earnings management

Dep. Variable =	*RDX*					
RSA =	*RSA1*			*RSA2*		
REM_RD subsample =	Low	Medium	High	Low	Medium	High
	(1)	(2)	(3)	(4)	(5)	(6)
TOBINQ	0.010***	0.002**	0.008***	0.010***	0.002*	0.008***
	(4.82)	(1.98)	(3.42)	(4.55)	(1.95)	(3.40)
TOBINQ×RSA	0.004**	0.001*	0.001	0.006**	0.001**	0.001
	(2.51)	(1.68)	(1.07)	(2.04)	(2.07)	(0.31)
TOBINQ×BIG4	−0.003	−0.001	0.001	−0.004*	−0.001	0.001
	(−1.55)	(−0.96)	(0.28)	(−1.81)	(−1.03)	(0.40)
TOBINQ×ISA	0.001	0.000	−0.003*	0.001	0.000	−0.003*
	(0.38)	(0.39)	(−1.91)	(0.49)	(0.39)	(−1.87)
TOBINQ×TENURE	0.000	0.000	0.000*	0.000	0.000	0.000*
	(0.83)	(0.55)	(1.66)	(0.88)	(0.61)	(1.72)
RSA	−0.007*	−0.001	−0.003	−0.009	−0.001*	−0.001
	(−1.94)	(−1.23)	(−1.01)	(−1.51)	(−1.86)	(−0.19)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,493	11,321	8,478	8,493	11,321	8,478
Adjusted R-squared	0.787	0.932	0.823	0.787	0.932	0.822

Panel C. Moderating effect of stock price informativeness

Dep. Variable =	*RDX*					
RSA =	*RSA1*			*RSA2*		
SPI subsample =	Low (1)	Medium (2)	High (3)	Low (4)	Medium (5)	High (6)
TOBINQ	0.001	0.008***	0.009***	0.001	0.008***	0.009***
	(0.26)	(4.01)	(4.04)	(0.20)	(3.82)	(3.77)
TOBINQ×*RSA*	0.003**	0.004**	0.006***	0.004**	0.005**	0.005
	(2.50)	(2.38)	(3.10)	(2.02)	(2.03)	(1.24)
TOBINQ×*BIG4*	0.001	0.002	−0.003	0.001	0.002	−0.003
	(0.23)	(1.06)	(−1.31)	(0.23)	(0.79)	(−0.95)
TOBINQ×*ISA*	0.002	0.000	0.002	0.002	0.000	0.002
	(1.14)	(0.02)	(0.53)	(1.24)	(0.10)	(0.69)
TOBINQ×*TENURE*	0.000	0.000	0.001*	0.000*	0.000	0.001**
	(1.55)	(0.35)	(1.92)	(1.67)	(0.51)	(2.12)
RSA	−0.007***	−0.008***	−0.010**	−0.008***	−0.011***	−0.008
	(−2.90)	(−2.85)	(−2.54)	(−2.64)	(−2.59)	(−1.26)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,297	12,389	9,285	9,297	12,389	9,285
Adjusted R-squared	0.874	0.838	0.830	0.873	0.838	0.830

This table presents the results of cross-sectional analyses. In Panel A, *RSA* is decomposed by the source of specialization: specialization that develops from clients with longer (*RSA_LONGTEN*) or shorter (*RSA_SHORTTEN*) tenures based on whether auditor tenure is longer than or within two years, and specialization that develops from clients with products more (*RSA_SIMHIGH*) or less (*RSA_SIMLOW*) similar to the focal client's based on the median values of the product similarity score. Panel B presents the results of a cross-sectional analysis based on the level of R&D-based real earnings management (*REM_RD*). Panel C presents the results of a cross-sectional analysis based on the level of stock price informativeness (*SPI*). In all panels, low, medium, and high subsamples are divided based on the 30th and 70th percentile values of each moderating variable. The definitions of all variables are provided in the Appendix. The figures in parentheses represent *t*-statistics calculated based on standard errors clustered by firm. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

we interpret our cross-sectional analyses as providing greater support for the monitoring channel over the disclosure quality channel.

Future innovative activities and firm performance

We further explore the consequences of R&D investments made by clients of R&D specialist auditors. If R&D specialist auditors induce more effective R&D investments, we expect the clients to produce more innovative output. We test this expectation using two proxies. The first is the quantity of patents, *INNPAT*, defined as the natural logarithm of one plus the number of patents filed in a given year. The second is the quality of patents, *INNCITE*, defined as the natural logarithm of one plus the number of citations received on the patents in a given year. Data on patents and patent citations are provided by Kogan et al. (2017).[21] We examine whether R&D specialist auditors strengthen the association between R&D investments and future innovative output by estimating the following equation.

$$INNPAT/INNCITE_{i,t+1(t+2)} = \beta_0 + \beta_1 RDX_{it} + \beta_2 RDX_{it} \times RSA_{it} + \beta_3 RSA_{it} + \Sigma\beta Controls_{it} + Year\ FE + Firm\ FE + \varepsilon_{it} \quad (5)$$

For firm *i* and year *t*, the variable of interest is *RDX*×*RSA*. We expect the coefficient β_2 to be positive. Control variables are included following prior research (e.g., Fang et al., 2014).[22]

Table 6 presents the results of estimating Equation (5). The dependent variable is *INNPAT* [*INNCITE*] for years *t*+1 and *t*+2 in Columns (1) and (2) [(3) and (4)], respectively. In Column (1), the coefficient on RDX is negative and statistically insignificant (coefficient = −0.062; *t*-statistic = −0.54), suggesting that spending more resources on R&D activities does not necessarily lead to more innovation output in the subsequent year. More notably, the coefficient on *RDX*×*RSA1* is significantly positive (coefficient = 0.245; *t*-statistic = 2.46), suggesting that an R&D specialist auditor helps improve R&D investment productivity. The results for year *t*+2 in Column (2) are consistent with those in Column (1), but the statistical significance becomes weak (coefficient = 0.145, *t*-statistic = 1.37). We find similar results using *INNCITE* as the dependent variable in Columns (3) and (4) and *RSA2* as the test variable (untabulated).

[21] The data are available at: https://github.com/KPSS2017/Technological-Innovation-Resource-Allocation-and-Growth-Extended-Data.

[22] Specifically, we control for firm size (*SIZE*), return on assets (*ROA*), book value of property, plant, and equipment (*PPE*), leverage (*LEV*), capital expenditures (*CAPX*), the raw and squared terms of the Herfindahl–Hirschman index (*HHI* and *HHI_SQ*), the Kaplan and Zingales' (1997) index for financial distress (*KZINDEX*), firm age (*AGE*), Amihud's (2002) illiquidity measure (*AMIHUD*), Big 4 auditor (*BIG4*), industry specialist auditor (*ISA*), and auditor tenure (*TENURE*). The detailed definitions of the variables are provided in the Appendix.

Table 6
Innovative outputs.

Dep. Variable =	$INNPAT_{t+1}$ (1)	$INNPAT_{t+2}$ (2)	$INNCITE_{t+1}$ (3)	$INNCITE_{t+2}$ (4)
RDX	−0.062	−0.020	0.072	0.024
	(−0.54)	(−0.16)	(0.55)	(0.16)
RDX×RSA1	0.245**	0.145	0.295**	0.230*
	(2.46)	(1.37)	(2.35)	(1.65)
RSA1	−0.011	−0.013	0.109***	−0.029**
	(−0.92)	(−1.06)	(9.59)	(−2.07)
SIZE	0.125***	0.105***	−0.069**	0.087***
	(11.88)	(9.73)	(−2.05)	(7.30)
ROA	−0.017	−0.006	0.248**	−0.089**
	(−0.61)	(−0.21)	(2.36)	(−2.50)
PPE	0.198**	0.153*	−0.082	0.148
	(2.16)	(1.71)	(−1.41)	(1.39)
LEV	−0.043	−0.050	0.032*	−0.070
	(−0.83)	(−0.95)	(1.94)	(−1.14)
CAPX	0.023	0.013	−0.032	0.013
	(1.61)	(0.89)	(−0.24)	(0.75)
HHI	−0.031	−0.053	0.032	0.004
	(−0.26)	(−0.43)	(0.21)	(0.03)
HHI_SQ	0.032	0.050	0.000	0.022
	(0.24)	(0.36)	(1.04)	(0.14)
KZINDEX	0.000***	0.000**	0.010	0.000
	(2.93)	(2.54)	(1.59)	(0.50)
AGE	0.004	0.004	0.015***	0.009
	(0.59)	(0.57)	(2.73)	(1.55)
AMIHUD	0.021***	0.015***	0.018	0.017**
	(3.56)	(2.77)	(0.55)	(2.53)
BIG4	0.004	−0.013	0.007	−0.011
	(0.13)	(−0.46)	(0.44)	(−0.36)
ISA	0.014	−0.001	−0.007**	−0.010
	(0.85)	(−0.06)	(−2.30)	(−0.57)
TENURE	−0.000	−0.002	−0.081	−0.008**
	(−0.15)	(−0.63)	(−0.55)	(−2.50)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	28,468	26,325	28,468	26,325
Adjusted R^2	0.885	0.890	0.844	0.842

This table presents the results of examining the effect of R&D specialist auditors on the number of patents and patent citations. Dependent variables are measured as of years *t*+1 and *t*+2 in odd and even columns, respectively. The definitions of all variables are provided in the Appendix. The figures in parentheses represent *t*-statistics calculated based on standard errors clustered by firm. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In untabulated tests, we examine the productivity of R&D investments in terms of future performance. We replace the dependent variable in Equation (5) with operating cash flows (*CFO*), return on assets (*ROA*), or market-adjusted returns (*CAR*) in years *t*+1 and *t*+2.[23] For all proxies, we find that the coefficient on *RDX* is significantly negative but that on *RDX×RSA* is significantly positive, suggesting that R&D specialist auditors mitigate the short-term negative effect of R&D investments on future performance. Collectively, the above results suggest that clients of R&D specialist auditors enjoy enhanced productivity of R&D investment in terms of innovative output as well as firm performance in the future.

Other analyses

Prior studies show that the benefits of an auditor's specialization are more pronounced at the audit office level, where auditors' knowledge and experience are accumulated, than at the audit firm level (Francis et al., 2005; Reichelt and Wang, 2010). Building on this literature, we examine whether our results are more pronounced at the audit office level. We measure an auditor's office-level R&D expertise, where an audit office is defined as the auditor of peer firms in the same Metropolitan Statistical Area. In untabulated analyses, we find that audit office-level R&D expertise has an incremental effect over firm-level expertise on the client's R&D investment-q sensitivity, which is consistent with auditors' specialization being developed through knowledge sharing within the audit office.

To confirm the robustness of our findings, we perform the following sensitivity analyses (untabulated). We control for auditor fixed effects to exploit within-auditor variation in our regressions, which helps minimize the effects of time-

[23] In our tests of operating or stock market performance, we add controls for market-to-book ratio (*BTM*), sales growth (*SGR*), total accruals (*TACC*), and return volatility (*RETVOL*) to Equation (5).

invariant, unobservable auditor characteristics. Additionally, we control for auditors' industry specialization within the TNIC industry (*ISA_TNIC*) to ensure that our results are not driven by differences in industry classification for identifying *RSA* and *ISA*.[24] The results of both tests are consistent with the main findings.

Conclusion

This study provides suggestive evidence that auditors' specialization benefits clients' investment decisions. Auditors who specialize in R&D activities may discipline clients and influence them to make better R&D investment decisions, which is indicated by higher R&D investment-q sensitivity. We also demonstrate that auditors' effective monitoring of R&D investments is one potential channel through which R&D specialist auditors are associated with improvements in corporate R&D decisions.

Although auditors are responsible for auditing financial statements, their effect is not restricted to financial reporting. As shown in this study, the auditors' disciplinary role may be valuable especially for clients with complex activities, such as R&D investments, involving greater uncertainty. As information is a fundamental block of all economic decisions, the fact that an auditor helps improve the efficiency of decision-making may not necessarily be surprising. However, there is limited evidence that directly supports this deduction. Our study can help extend the understanding of auditors' role in capital markets, improving firms' decision-making capability.

Our results are subject to the following caveats. Our measure of auditors' R&D specialization may be incomplete to the extent that R&D investment does not necessarily result in successful innovation. Moreover, we infer the auditors' disciplinary role by examining the sensitivity of R&D investments to investment opportunities because direct evidence is unavailable on the detailed R&D process that occurs in practice. The evidence on the hypothesized channels is only suggestive and does not completely confirm or reject certain channels. Finally, despite our attempts to control for the effect of client characteristics via various approaches such as DiD analysis, PSM, and entropy balancing, other correlated omitted variables, such as unobservable market-wide factors affecting both clients and auditors, may bias our results. We hope future studies to delve further into the issue to elucidate auditors' role in R&D activities more comprehensively.

CRediT authorship contribution statement

Eugenia Y. Lee: Investigation, Project administration, Writing – original draft. **Wonsuk Ha:** Conceptualization, Data curation, Formal analysis, Supervision, Writing – review & editing. **Sunyoung Park:** Methodology, Validation.

Data availability

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Definitions of Variables

Variable	Definition
Variables for main analysis	
RDX	=R&D expenses scaled by lagged total assets
RSA_SHARE	=Auditor's share in the client's R&D market, calculated as the sum of lagged R&D expenses of the client's product market peers audited by the auditor in the previous year scaled by the sum of lagged R&D expenses of all of the client's product market peersA firm's product market peers are identified according to Hoberg and Phillips' (2016) text-based network industry classifications (TNIC), available at: https://hobergphillips.tuck.dartmouth.edu/industryclass.htm
RSA1	=Indicator variable that equals 1 if *RSA_SHARE* exceeds 0.2 and 0 otherwise
RSA2	=Scale-adjusted decile rank of *RSA_SHARE*, ranging between 0 and 1. Firms with zero values of *RSA_SHARE* are assigned to the bottom decile and the remaining firms with positive values of *RSA_SHARE* to the other deciles

(*continued on next page*)

24 Specifically, we identify industry specialist auditors as auditors whose TNIC market share (sum of audit fees of TNIC peers audited by the auditor scaled by the sum of audit fees of all TNIC peers) exceeds 0.2.

Appendix (*continued*)

Variable	Definition
TOBINQ	=Sum of the market value of equity and book value of liabilities, scaled by the book value of total assets
INVTA_L1	=Inverse of lagged total assets
SIZE	=Natural logarithm of the market value of equity
CF	=Sum of earnings before extraordinary items, depreciation and amortization expenses, and R&D expenses, scaled by lagged total assets
CAR	=Market-adjusted stock returns measured over the fiscal year
BIG4	=Indicator variable that equals one if a firm's incumbent auditor is one of the Big 4 auditors and zero otherwise
ISA	=Indicator variable that equals one if a firm's incumbent auditor is an industry specialist auditor and zero otherwise. An industry specialist auditor is defined as the auditor who has the largest market share in terms of audit fees in a given industry-year, with the share being at least 10% larger than the second-largest auditor's market share
TENURE	=Number of consecutive years for which the incumbent auditor has audited a firm
Variables for additional analyses (in order of appearance)	
REM_RD	=The residual from the following equation, estimated for each industry-year with at least 15 observations, following Gunny (2010), multiplied by (−1): $RDX_{i,t}/TA_{i,t-1} = \beta_0 + \beta_1(1/TA_{i,t-1}) + \beta_2 SIZE_{i,t} + \beta_3 TOBINQ_{i,t} + \beta_4 CF_{i,t}/TA_{i,t-1} + \beta_5 RDX_{i,t-1}/TA_{i,t-1} + \varepsilon_{it}$, where *TA* is total assets
SPI	=Return non-synchronicity, calculated as $\ln\left\{\left(1-R^2\right)/R^2\right\}$, where R^2 is estimated for each firm-year using the following equation (Morck et al., 2000): $RET_{i,w} = \beta_0 + \beta_1 RET_{m,w} + \beta_2 RET_{m,w-1} + \beta_3 RET_{m,w+1} + \beta_4 RET_{j,w} + \beta_5 RET_{j,w-1} + \beta_6 RET_{j,w+1} + \varepsilon_{it}$ for firm *i*, market *m*, industry *j*, and week *w*, and *RET* is the raw return
RSA_LONGTEN [*RSA_SHORTTEN*]	=*RSA* that is measured with a firm's product market peers that maintain a long tenure (more than two years) [short tenure (one or two years)] with the incumbent auditor
RSA_SIMHIGH [*RSA_SIMLOW*]	=*RSA* that is measured with a firm's product market peers audited by the auditor in the previous year and has a product similarity score above [below] the sample median, as measured by Hoberg and Phillips (2016)
INNPAT	=Natural logarithm of one plus the number of patents filed by the firm during a given fiscal year
INNCITE	=Natural logarithm of one plus the number of citations received on a firm's patents during a given fiscal year
ROA	=Earnings before extraordinary items scaled by total assets
PPE	=Net property, plant, and equipment scaled by total assets
LEV	=Book value of long- and short-term debts scaled by the book value of equity
HHI	=Herfindahl–Hirschman index of market shares within the product market, where market shares are calculated based on sales
HHI_SQ	=Squared term of *HHI*
KZINDEX	=Kaplan and Zingales' (1997) proxy for financial constraints
AGE	=Firm age, calculated as the number of years since a firm's initial appearance in the CRSP database
AMIHUD	=Amihud's (2002) illiquidity measure
CFO	=Operating cash flows scaled by lagged total assets
MTB	=Market value of equity scaled by the book value of equity
SGR	=Annual change in sales scaled by the prior-year sales
TACC	=Net income less operating cash flows scaled by lagged total assets
RETVOL	=Standard deviation of monthly stock returns during the fiscal year

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