Corporate Innovation and Audit Fees

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Abstract

Economic literature documents that the investment rate of intangibles has exceeded that of tangible assets in the U.S. private sector since the mid-1990s. However, whether or how the increasing intangibles created by innovative activities affect audit process and pricing have not been empirically examined yet. This study investigates whether the features of corporate innovation (e.g., complexity, efficiency, or obsolescence) are associated with audit fees. Using patent-based metrics to measure the features of innovation within firms, we find that the complexity of corporate innovation is positively associated with audit fees, while auditors do not charge higher fees for clients with greater research and development (R&D) intensity. Firms that can more efficiently convert R&D inputs into innovation outputs, which are measured by the number, citation frequency, and economic value of patents, are associated with lower audit fees. Furthermore, firms holding more aged patent portfolio are associated with higher audit fees.

Keywords: audit fees; intangible assets; innovation; efficiency

Data Availability: All data are available from the sources indicated in the text.

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I. INTRODUCTION

In the era of a knowledge-based economy, companies keep increasing investments in research and development (R&D) activities to gain and maintain competitive advantage over their rivals and earn abnormal returns (Lev 2001; Hand and Lev 2003). The rate of investment in intangibles has exceeded that in tangible assets in the United States (U.S.) private sector since the mid-1990s (Corrado and Hulten 2010, 2014; Lev and Gu 2016). Intangible assets, such as patents and licenses, reflect the successful results of innovation and often account for a significant proportion of economic resources in companies, especially among those in high-tech sectors such as information technology or pharmaceutical industries. Accounting for intangibles and related activities, however, relies heavily on accounting estimates (e.g., the achievement of technological feasibility, estimated useful life, and estimated future cash flows) that can be subject to management bias (Selling and Nordlund 2015; Sacer, Malis, and Pavic 2016). Auditors, as a result, also face the challenges of assessing and verifying intangible assets, especially those developed internally through innovative activities. Indeed, the Director of the Public Company Accounting Oversight Board (PCAOB), Helen Munter, in her December 6, 2017 speech, pointed out that recurring deficiencies in auditing accounting estimates is one of the three significant deficiencies found in PCAOB inspections (Munter 2017). The PCAOB consistently identified inadequate testing of fair value estimates performed by audit firms since 2004 in its reports (PCAOB 2008, 2010, 2015, 2016, 2017). As fair value estimates affect valuation and subsequent impairments for intangibles and other long-lived assets, failing to collect related evidence and make adequate assessments will expose audit firms to reputation loss and legal actions (Collins, Lawrence, and Cagle 2015).

This paper is motivated by the difficulties the auditors face when evaluating intangibles and R&D activities and focuses on whether or how the internally developed intangibles reflecting the innovation of a company affect the audit process and audit pricing strategies. Specifically, we examine whether the features of corporate innovation, namely the *complexity* of R&D activities, the *obsolescence* of innovation results, and the *efficiency* of generating innovation outputs, are associated with audit fees.

Patent, as a specific type of intangibles, is often employed to measure corporate innovation in the extant literature (e.g., Hirshleifer, Hsu, and Li 2013; Kogan, Papanikolaou, Seru, and Stoffman 2017). In 1982, the formation of the Court of Appeals for the Federal Circuit substantially strengthened the judicial treatment of patent rights, which spawned patent portfolio races in the U.S. (Hall and Ziedonis 2001; Hall 2005). As U.S. firms have been more actively patenting their innovation since the mid-1980s, patents are considered the most important and direct measure of the inventive output of corporate R&D activities (Griliches 1990). On the other hand, R&D spending may not be a good measure of corporate innovation activity because approximately 10.5% of firms that have missing R&D expenditures receive patents (Koh and Reeb 2015). Thus, we use the following three patent-based metrics to measure the *complexity* of corporate innovation activities: (1) the number count of patents, (2) the number of forward citations of its patents, and (3) the economic value of the patents based on the stock returns over a three-day window around the patent issuance announcement. The number of patents is simply the quantity of patents without regards to their importance or viability. The forward citations of patents consider the scientific importance of the patent innovation and the economic value of patents takes market expectation over future economic outcome of corporate innovation into account (Kogan et al. 2017). In addition, we employ the number of technology classes of patents granted to measure the *scope* of corporate innovation and assume firms with broader scope of R&D activities exhibit a higher degree of complexity for auditing.

We draw a sample of audits of 2,003 companies holding utility patents from fiscal years 2000 to 2010 to evaluate how corporate innovation affect audit pricing decisions. The results show that all four patent-based measures of innovation are positively associated with audit fees, suggesting that firms with more and broader R&D activities may exhibit a higher degree of innovation complexity and require greater audit effort.

We also examine the association between innovation *efficiency* and audit fees since the efficiency of converting R&D inputs to successful innovation results could affect the auditors' risk assessment, pricing, and fieldwork strategies. Hirshleifer et al. (2013) develop metrics for innovation efficiency based on the number of patents and citations per dollar of R&D expenditure. They test and document a positive association between innovation efficiency and future financial performance and stock returns, suggesting that innovation efficiency is one of the factors to change market perception of future firm performance. We follow their design to construct the measures of corporate innovation efficiency using respective innovation metrics (e.g., number count of patents) divided by a company's prior five-year cumulative R&D expenses. As the efficiency of corporate innovation reflects how a company manages uncertainty in R&D projects, we expect that it affects not only investors' perception but also auditors' risk assessment, and therefore should affect audit planning and audit fees. Consistent with the hypothesis, we find that audit fees are negatively associated with innovation efficiency.

Finally, we investigate whether technological obsolescence of corporate innovation is associated with audit fees. The Financial Accounting Standards Board's (FASB) Accounting Standards Codification (ASC) section 350 requires that, when estimating the useful life of an intangible asset, management should consider legal or regulatory provisions that may limit the useful life, the effects of obsolescence, market competition, and other economic factors. Auditors must collect sufficient and competent evidence about the existence and value of intangible assets including the related management estimates. In the U.S., the term of a patent is twenty years from the application filing date for the utility patents filed on or after June 8, 1995 and is either twenty years from the filing date or seventeen years from the patent grant date for utility patents filed before June 8, 1995.[1] The uncertainty of practicality and profitability of a patent could decrease with the patent's age, which reduce the difficulties for auditors to evaluate clients' innovation results and reporting. However, technology and market competition may also change over time to make the patent obsolete or reduce the future cash flows the patent can generate. Consequently, auditors make more effort to collect adequate evidence to validate the value of more aged patent portfolios and charge higher auditor fees. Consistent with this prediction, we find that the average age of patents is positively associated with audit fees.

This paper contributes to the extant audit literature on the fundamental determinants of audit fees. Prior research has documented that a variety of client characteristics, such as client size, complexity, and inherent risk, are associated with audit fees (e.g., Hay, Knechel, and Wong 2006). In this study, we find that features of corporate innovation; namely, *complexity*, *efficiency*, and *obsolescence*, have a significant impact on auditors' risk assessment, efforts, and pricing strategies. This paper also contributes to the growing accounting literature on R&D investments and intangible assets (e.g., Roone and Raman 2001; Gelb 2002; Ballester, Carcia-Ayuso, and Livnat 2003; Gu and Wang 2005; Amir, Guan, and Livne 2007; Selling and Nordlund 2015; Sacer et al. 2016; Stein 2019). Overall, auditors perceive that firms with a greater quantity and broader scope

[1] https://www.uspto.gov/web/offices/pac/mpep/s2701.html

of innovation exhibit a high degree of innovation complexity and complete audit work with more efforts and higher fees. Firms with higher innovation efficiency reflect their ability of generating more inventive outputs for a given amount of R&D investments, change market and auditors' perception, and therefore are charged with lower audit fees. Furthermore, technological obsolescence of corporate innovation, measured by the average age of patent portfolio, is associated with higher audit fees.

The remainder of the paper is organized as follows. Section II reviews prior literature and develops the theoretical hypotheses on the relation between corporate innovation and audit pricing. Section III presents the research design and describes our research sample. Section IV details the empirical results. Section V reports additional analyses and Section VI summarizes main findings and conclusions.

II. LITERATURE REVIEW AND THEORETICAL DEVELOPMENT

The rapid advancement of technology through innovation is easy to see and impacts all walks of daily life. The valuation of corporate innovation, however, is somewhat difficult for management, investors, auditors, and other financial report users to make because uncertainty is intrinsic to innovation and R&D activities. Most prior literature addresses corporate innovation solely from input or output of R&D activities by focusing on R&D expenditure and specific type of intangible assets, such as patent, copyright, or goodwill, respectively. Some studies document that capitalized R&D is a credible signal of success likelihood of corporate innovation based on simulation (Healy, Myers, and Howe 2002) and non-U.S. data (Oswald and Zarowin 2007; Oswald 2008). Current U.S. Generally Accepted Accounting Principles (GAAP), however, require most

R&D expenditure expensed immediately when incurred (ASC 730).[2] In addition, companies are only required to report material R&D expenses either in the income statement or in a footnote. By comparing patent records and R&D expenditures, Koh and Reeb (2015) document that 10.5% of firms missing R&D reporting receive patents 14 times greater than zero R&D firms, suggesting firms may limit the availability of proprietary cost information to competitors (Leuz and Verrechia 2000). As a result, R&D expenditure is an imprecise measure of corporate innovation capability.

Prior research also uses intangibles as the proxy for innovative output for which the patent is a prominently used direct measure (Griliches 1990). However, most studies in this research stream focus on the determinants of innovation, such as financial dependence (Acharya and Xu 2017), transparency (Zhong 2018), foreign institutional ownership (Luong, Moshirian, Nguyen, Tian, and Zhang 2017), financial market development (Hsu, Tian, and Xu 2014) or other firm characteristics, rather than the effects of corporate innovation. Using patent-based and citation-based metrics, Hirshleifer et al. (2013) consider the input and output of R&D activities simultaneously to measure the efficiency of corporate innovation. They document that innovation efficiency is a strong predictor of future stock returns, after controlling for firm risk and other characteristics, but that investors misprice the value of innovation efficiency. The following arguments can explain their findings. First, the market tends to underreact to information about innovation efficiency due to the difficulties explaining the economic implications of innovation outcomes, such as patent and patent citations. Second, as past innovation efficiency is a proxy for risk, firms with higher innovation efficiency (and lower risk) should be productive in patenting

[2] There are still exceptions. For example, certain R&D spending related to software development may be capitalized under ASC 985.

(Dierickx and Cool 1989) subsequently to maintain higher profits and stock returns. Both imply a positive association between innovation efficiency and stock returns.

Another stream of literature discusses the attributes of firms affecting auditors' perception, risk assessment, workload and efforts leading to the changes of audit fees. For instance, Hay et al. (2006) summarizes audit pricing literature on the determinants of audit fees. Researchers typically expect that the audit fees are positively associated with client complexity and inherent risk (Simunic 1980). The number of business segments and the level of operations in foreign locations are often used as the proxies for client complexity and auditors are expected to spend more time to finish auditing for complex clients (Hackenbrack and Knechel 1997). When clients are associated with higher inherent risk, the probability of material misstatements is higher and auditors often employ specialized procedures to complete the audit task (Newton and Ashton 1989). As auditors face loss exposure in the event that a client suddenly become unsuccessful, they should change the audit plan and charge their clients higher fees for more audit effort and risk premium.

Given the intrinsic uncertainty of R&D projects and the difficulty estimating future economic value of internally developed intangibles, we expect that the risk and attributes of a firm engaging in innovative activities are fundamentally changed. Such changes should affect not only market perception and stock returns (Hirshleifer et al. 2013) but also auditors' assessment of firm risk leading to the adjustment of audit plans, efforts, and pricing decisions.

The innovation capability of a firm can be measured from different dimensions based on patents, a common and direct measure of R&D output. For instance, some firms may focus on a specific field and invest heavily in related R&D activities which, if successful, could result in a large quantity of patents. The firms then create economic value by receiving licensing fees from other businesses utilizing the patents to provide products and services and the patents will receive multiple citations. Conversely, instead of pursuing specialization in an individual area, other firms may put R&D resources into multiple types of technologies to expand their scope of innovation and patent lines. This could be an effective strategy of risk diversification considering inconsistent risk and uncertainty in each R&D project. When there is technological breakthrough in a specific area and the economic value of related patents suddenly losses at all, the patents in other disciplines are still useful to sustain the firms' operating cash inflows.

Accordingly, we count the number of patents, the frequency of patent citations and the economic value of patents as three proxies for the *complexity* of corporate innovation. We also use the number of technology classes of patents to measure the *scope* of corporate innovation, an alternative dimension of innovation complexity. We investigate the effects of innovation *complexity* and *scope* on auditors' pricing strategies. As engaging in more innovation activities signals higher challenging and risky audit areas that requires more audit efforts, we expect a positive relation between corporate innovation and audit fees as stated in our first research hypothesis as follows:

H1. There is a positive relation between the complexity of corporate innovation and audit fees.

The *efficiency* of innovation is another measure of innovation capability simultaneously considering the input and output of R&D activities. It represents a firm's ability to generate intangible assets, such as patents and patent citations, per dollar of R&D expenditure and therefore reflects how a firm manages uncertainty intrinsic to the R&D projects and converts these projects to real economic value. Prior literature suggests that innovation efficiency is an indicator changing market perception of firm risk and is positively associated with firms' subsequent productivity of patenting (Dierickx and Cool 1989), future operating performance, and stock returns (Hirshleifer et al. 2013).

Information content of innovation efficiency is hard to process with high uncertainty. Prior research suggests that individuals pay less attention and weight to information that is hard to process (Song and Schwarz 2009) and investors tend to underreact to such information. However, auditors are professionals and risk assessment is an essential part of audit process. Auditors are expected to catch critical events altering clients' risk including R&D input and innovative outcomes. Similar to Hirshleifer et al. (2013) finding that innovation efficiency changes market perception, we expect that innovation efficiency containing distinct information about future potential and risk of a firm should also affect auditors' assessment of risk, audit plans, and charged fees. When a firm is more efficient in innovation, it means the uncertain R&D inputs in a firm are converted into intangibles with higher likelihood of generating future economic value more quickly than other firms with similar R&D investment and lower output. Because higher innovation efficiency signals lower client risk, we predict a negative relationship between innovation efficiency and audit fees. This leads to our second research hypothesis:

H2. There is a negative relation between the efficiency of corporate innovation and audit fees.

A firm invests in R&D projects with the expectation of generating future cash flows. Even if the R&D investments have reached technological feasibility and been capitalized, the subsequent valuation for these intangible assets, including the estimates of useful life, changes in expected future cash flows, recoverability, and impairment reporting, is still more difficult than that for tangible long-lived assets. As a result, the reporting of the intangibles, which represent the outcomes of corporate innovation, is uncertain and has lower predictability of future firm performance (Gordon and Hsu 2018). ASC 350 provides the guidance for the valuation of intangibles based on the useful life of the intangible asset to a firm over the period in which the asset is expected to contribute to the future cash flows. When estimating the useful life of an intangible asset, management should consider legal or regulatory provisions that may limit the useful life, the effects of obsolescence, competition, future expenditures needed to maintain the asset's ability of generating future cash flows, and other economic factors. We therefore expect that auditors take useful life, obsolescence status, and related issues into account when evaluating the value and risk of clients' innovation outcomes to determine audit fees.

Johnstone and Bedard (2004) investigate the effect of audit risk factors and clients' financial risk factors on audit firm portfolio management decision. They document that audit risk factors are more important than financial risk factors and large audit firms tend to accept less risky (Jones and Raghunandan 1998; Choi, Doogar, and Ganguly 2004) or risker clients (Francis and Reynolds 2002; Francis and Krishnan 2002) in different time periods. More mature patents could have a more predictable pattern of future cash flows due to a longer history of past cash flows, which could facilitate impairment analysis if using the income method and reduce audit risk. However, this would not be the case if the patents have not been put into production or if there have been no royalty payments. However, the obsolesce of innovation also makes a firm more difficult to maintain competitiveness in the market and could gradually increase financial risk. Maresch, Fink, and Harms (2016) document a negative association between patent age and firm performance. Because more mature patents represent more mature and possibly superseded technology, the age of a patent would be a negative factor in patent portfolio audits.[3] As auditors' pricing strategies are affected by these two conflicting factors, we do not have a directional prediction of the

[3] https://clarivate.com/wp-content/uploads/2017/10/IP_PatentPortfolioAudits_WhitePaper_A4_007.pdf (page 8-9).

association between audit fees and the age of patent portfolios, and present our hypothesis 3 in the null form as follows.

H3. There is no relation between the obsolescence of corporate innovation and audit fees.

III. RESEARCH DESIGN AND DATA

Empirical Model

We specify that the natural logarithm of audit fees (*Log(AF)*) is a function of corporate innovation and other control variables documented in prior research (e.g., Francis 1984; DeFond, Francis and Wong 2000; Hay et al. 2006; Taylor 2011). Kogan et al. (2017) construct two metrics for innovation based on 1,801,879 patents granted from 1926 to 2010. First, they estimate the value of the patent by isolating the stock market return around the news of the patent grant. Second, they compare the forward citations of the patents; that is, citation-weighted patents, to the market values reporting a significant positive relationship between the two. Moreover, Kogan et al. (2017) report a positive association between innovation output measured by citation-weighted patents and firm growth as evidenced by increases in profits, output, capital investment, employment, and productivity.

We utilize a patent database collected by Kogan et al. (2017) to measure the features of corporate innovation and the outcomes of R&D activities. Our first theoretical variable of interest is the *complexity* of corporate innovation. Because firms creating more innovation results need to invest heavily in various R&D projects and are likely to exhibit higher degree of complexity for auditors, we measure the complexity of innovation from two dimensions: (1) the natural logarithm of one plus patent counts (*Log(Patent)*) to measure the quantity of corporate innovation, (2) the natural logarithm of one plus the number of technology classes of patents granted (*Log(TECHCL)*) to measure the scope of innovation. Following the first hypothesis, we expect the coefficients on *Log(Patent)* and *Log(TECHCL)* to be significantly positive. In addition, we also use the natural logarithm of one plus citation-weighted patents (*Log(CPatent)*) and the natural logarithm of one plus market value weighted patents (*Log(VPatent)*) as defined in Kogan et al. (2017) to measure the quality-adjusted quantity of corporate innovation.[4]

Our second variable of interest is the *efficiency* of corporate innovation. Hirshleifer et al. (2013) use innovation efficiency to measure the prospects of new technologies or other innovations and document that firms with higher innovation efficiency have higher future operating performance and stock returns. Because clients with higher innovation efficiency tend to exhibit better financial performance, we expect that auditors would charge these clients lower fees for less inherent risk. As in Hirshleifer et al. (2013), we define innovation efficiency (*PEFF*) as the ratio of firm *i*'s patents granted in year *t* to the firm's prior 5-year cumulative R&D expenditures (*R&D*) with a 20% annual depreciation rate: $Patent_t/(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6})$. The 5-year cumulative R&D period starts in year *t-2* because it takes about two years after a patent application to grant the patent (Hall, Jaffe, and Trajtenberg 2001; Hirshleifer et al. 2013). As an example, the application for patent number 2,510,524, titled "Apparatus for Causing Variable Flow of Air in Treating Rooms," was filed on November 14, 1947 and the patent was granted to A. A. Schramm on June 6, 1950. Similarly, we define citation-weighted innovation efficiency (*CEFF*) as $CPatent_{i,t}/(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6})$,

[4] Kogan et al. (2017) construct a new measure based on the stock returns over the three-day window of the patent issuance announcement to quantify the dollar value of patents granted. Meanwhile, they define a citation-weighted patent measure using forward citations of patents. They show while the citation weighted patents is a commonly used measure for scientific value of innovation in prior research, their proposed market value weighted patent measure contains additional information on the economic value of innovation.

and define market value weighted innovation efficiency (*MVEFF*) as $VPatent_{i,t}/(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6})$.

The third variable of interest is the technological obsolescence of innovation, measured by the average age of a firm's patent portfolio. Because an aged patent portfolio signals falling behind on product innovation and lower future profitability, auditors may perceive that firms holding a more aged patent portfolio are associated with higher client risk and charge these firms higher audit fees. Conversely, older patents may produce a more predictable income stream than newer patents and therefore viewed as lower in risk. In the U.S., the term of utility patents is twenty years from the earliest application filing date and it, on average, takes two years to grant a patent application (Hall et al. 2001; Hirshleifer et al. 2013). We construct the average age of patent portfolio (*Vintage*) as $\sum_{k=0}^{18}(k+2)*Patent_{it-k}/\sum_{k=0}^{18}Patent_{it-k}$ where *Patent* represents the number of patents granted.[5] Due to the competing explanations for the age of the patent portfolio, no prediction is made for the sign of *Vintage*. Overall, our main research model is as follows:

$$Log(AF_{it}) = \beta_0 + \beta_1 Log(Patent_{it}) + \beta_2 Vintage_{it} + \beta_3 PEFF_{it} + \beta_4 BigN_{it} + \beta_5 BigN_{it} * Log(Patent_{it}) + \beta_6 Log(Duration_{it}) + \beta_7 RDINT_{it} + \beta_8 Size_{it} + \beta_9 Log(Segment_{it}) + \beta_{10} Foreign + \beta_{11} ROA_{it} + \beta_{12} Loss_{it} + \beta_{13} INVREC_{it} + \beta_{14} Quick_{it} + \beta_{15} Leverage_{it} + \beta_{16} Concern_{it} + \beta_{17} Log(NAF_{it}) + \beta_{18} December_{it} + \beta_{19} BtM_{it} + \beta_{20} SGrowth_{it} + \beta_{21} Litigation_{it} + \beta_{22} Log(Age_{it}) + \text{Industry Fixed effects} + \text{Year Fixed Effects} + \epsilon_{it} \quad (1)$$

We use the natural logarithm of average length of time between the filing and issuance dates of patents granted (*Log(Duration)*) to control for the innovation risks associated with patent application process. We include R&D intensity (*RDINT*) based on the ratio of R&D expenses to sales revenue, because prior research suggests that R&D intensity is positively associated with

[5] Here we assume that the patent granted in year t has an age of two and will have a term of eighteen years.

accrual-based earnings management (Shust 2015). Meanwhile, we include a vector of variables documented in prior research to control for various factors that also determine the audit fees (see Hay et al. 2006 for a detailed review). We first include the natural logarithm of total assets (*Size*) to control for client size, because larger clients require more audit work and are associated with greater audit fees (Palmrose 1986). In addition, we use the natural logarithm of business segments (*Log(Segment)*) and an indicator variable for foreign operations (*Foreign*) to control for client complexity and expect positive coefficients on both variables. We use returns on assets (*ROA*) and an indicator variable for loss (*Loss*) to control for the profitability of clients. As clients with better financial performance tend to be less risky, we expect a negative coefficient on *ROA* and a positive coefficient on *Loss*. We include the ratio of inventory and receivables to total assets (*INVREC*) to control for client operational efficiency and expect the coefficient to be positive. We include two financial ratios, the ratio of current assets less inventories to total current liabilities (*Quick*) and the ratio of total debt to total assets (*Leverage*), to control for clients' ability to meet their short-term and long-term financial obligations, respectively. Because clients with higher quick ratio are more likely to be able to meet short-term financial obligations, we expect a negative coefficient on *Quick*. Firms with higher leverage ratio tend to exhibit higher inherent risk and auditors are likely to charge higher fees for clients. Thus, we expect the coefficient on *Leverage* to be positive.

We include the indicator of going concern opinions (*Concern*) to control for the financial distress of clients and expect the coefficient to be positive. We include the natural logarithm of non-audit fees (*Log(NAF)*) to control for the impact of non-audit services on the pricing of audit services (Whisenant, Sankaraguruswamy, and Raghunandan 2003; Basioudis and Francis 2007). Because many public US firms' fiscal year ends in December, we include an indicator variable, *December*, to control for the effect of auditor capacity constraint on audit pricing during the busy season. We include book to market value ratio (*BtM*) and sales growth (*SGrowth*) to control for firm's growth opportunities and expect negative coefficients on both variables (Choi, Kim, and Zang 2010; Krishnan and Wang 2015). We include an indicator variable, *Litigation*, to control for the effect of operating in high litigation risk industries and expect the coefficient to be positive (Bentley, Omer, and Sharp 2013). We include the natural logarithm of the number of years that a firm has been publicly listed (*Log*(*Age)*) in the audit fee model and do not have a prediction on its sign (e.g., Krishnan and Wang 2015). Table 1 presents the detailed definitions of dependent and independent variables above.

[Insert Table 1]

Data and Research Sample

Our initial research sample is drawn from the Compustat Fundamentals Annual and Audit Analytics databases during the period 2000-2010. We collect firms' operational and financial data from the Compustat Fundamentals Annual files and their audit fee data from the Audit Analytics database. The innovation database is collected by Kogan et al. (2017), consisting of all utility patents issued by the United States Patent and Trademark Office (USPTO) from 1926 to 2010. Because the audit fee data in Audit Analytics are not available before 2000, we choose a sample period from 2000 to 2010. The initial sample drawn from Compustat and Audit Analytics databases consists of 122,652 firm year observations. Following prior research, we first exclude financial institutions (SIC codes 6000-6999) and utility firms (SIC codes 4900-4999) because these industries are heavily regulated. Then we drop the firm year observations with missing audit fee or missing patent data. Next, we delete the firm observations with missing prior year R&D expenses when constructing the innovation efficiency measure and remove the firm year observations with missing values on other independent variables. In the end, our final research sample consists of 2,003 firms and 9,319 firm year observations for regression analyses.

[Insert Table 2]

Table 3 shows the descriptive statistics of the dependent and independent variables of our final research sample. The raw means of audit fees (*AF*), non-audit fees (*NAF*) and total assets are 2.33, 1.10, and 5,291.25 million dollars, respectively. The sample mean and median of patent counts (*Patent*) are 52.36 and 5, suggesting the distribution of patent counts is highly positively skewed. That is a relative small number of firms are granted more patents than other firms. Similarly, the distributions of *CPatent*, *VPatent*, *TECHCL*, *PEFF*, *CEFF*, *VEFF*, and R&D intensity (*RDINT*) are also positively skewed. These results suggest that the inputs and gains of innovation activities are not evenly distributed among firms, and a small number of firms are more innovative than other firms. The sample mean of *Duration* shows that it on average take 1,155.2 days for a patent to be granted after the filing of the patent. On average, 89.0% of firms are audited by one of big name auditors, 68.6% of firms are audited in December, and 3.2% of them are issued going concern opinion.

[Insert Table 3]

Table 4 presents the correlation matrix between audit fees, innovation related variables and other independent variables. As we can see, audit fees are positively correlated with innovation complexity measures, including patent counts, citation weighted patents, market value weighted patents and number of technology classes. Interestingly, R&D intensity (*RDINT*) is negatively associated with audit fees. In other words, firms with high R&D intensity are associated with lower audit fees, suggesting that R&D input itself is not a good measure of innovation complexity. Regarding innovation efficiency, audit fees are negatively associated with both patent efficiency

(*PEFF*) and citation-weighted innovation efficiency (*CEFF*), but positively associated with market value weighted innovation efficiency (*VEFF*). The waiting time between filing and grant dates of patents (*Duration*) is positively associated with audit fees, implying that auditors may consider the risk associated with application process for their audit pricing decisions. The Pearson correlation coefficient between *Patent* and *CPatent* is 0.983, and the correlation coefficient between *Patent* and *VPatent* is 0.358. However, the spearman correlation coefficient between *Patent* and *VPatent* is 0.824. This is consistent with Kogan et al.'s (2017) argument that their market value weighted patents measure contains incremental information content of innovation compared to patent counts and citation weighted patents. In addition, the Pearson correlation coefficients between *Patent* and *Size* is 0.361, suggesting that larger firms tend to engage in more R&D activities. Overall, there is no extremely high correlations between our variables of interests and other control variables.

IV. EMPIRICAL RESULTS

We first use patent counts (*Patent*) as a proxy for innovation complexity and run the pooled OLS regression to estimate the audit fee model. We winsorize continuous independent variables at 1% levels to reduce the impact of outlier observations on coefficient estimates. Standard errors are two-way clustered by firm and year to make robust statistical inference. In addition, we included both industry and year fixed effects in the audit fee model to control for the common factors that would affect the pricing of audit services at industry and year levels. The regression results are presented in Table 5.

Column (1) of Table 5 shows the effect of innovation complexity on audit fees using patent counts (*Log(Patent)*) to measure innovation complexity, and Column (3) presents the results using the number of technology classes (*Log(TECHCL)*) as a proxy for innovation complexity. Columns

(2) and (4) presents the t-statistics of coefficient estimates in Columns (1) and (3) respectively. In Column (1), the mean variance inflation factor (VIF) of all independent variables is 1.74, and the VIF of *Size* is 4, the highest VIF, which is far less than the rule of thumb cutoff, 10 (Hair et al., 2006). Similarly, the mean and highest VIF of independent variables are 1.73 and 3.89 in Column (3). This suggests that multi-collinearity is not an issue in our audit fee model. However, when both *Log(Patent)* and *Log(TECHCL)* are included in the audit fee model, the VIF of *Log(Patent)* and *Log(TECHCL)* are 12.55 and 12.43, suggesting the existence of multi-collinearity due to the high correlation between *Log(Patent)* and *Log(TECHCL).*

As Table 5 shows, the coefficient estimates on *Log(Patent)* and *Log(TECHCL)* are both significantly positive at the 1% level, consistent with our first hypothesis that auditor charge their clients more fees for higher complexity of innovation. The coefficient estimates on patent innovation efficiency (*PEFF*) are significantly negative at the 1% level for the two regression models in Table 5. This supports the second research hypothesis that auditors charge lower fees for the clients with higher innovation efficiency. The coefficient estimates on the average age of a firm's patent portfolio (Vintage) are both significantly positive at the 1% level. Thus, auditors view the age of patent portfolio as a risk factor and exert more effort to assure the economic value of patents and quality of financial reporting. In addition, the coefficient estimates on *Log(Duration)* are all small and not significantly different from zero, suggesting that the average duration of receiving a patent does not substantially change auditors' perception of innovation risk. Interestingly, the coefficient estimates on R&D intensity (*RDINT*) are also not significantly in all the four audit fee models. This suggests that the R&D inputs of innovation activities do not significantly affect auditors' assessment of innovation complexity. The coefficient estimates on

Big N auditors (*BigN*) are significantly positive, consistent with prior research suggesting that Big N auditors charge their clients premium prices for higher audit quality.

[Insert Table 5]

Table 6 presents the results when we use two alternative measures that consider the quality of innovation. Column (1) of Table 6 show the effect of innovation complexity on audit fees when citation weighted patent counts (*Log(CPatent)*) is used to measure innovation complexity, and Column (3) shows the results when market value weighted patent counts (*Log(VPatent)*) is used. Consistent with the results in Table 5, the coefficient estimates on *Log(CPatent)* and *Log(VPatent)* are significantly positive at the 1% level. The coefficient estimates on citation-weighted innovation efficiency *(CEFF*) and market value weighted patent efficiency (*VEFF*) are significantly negative at the 1% level. This suggests that our results are consistent across alternative measures of innovation complexity and efficiency. Meanwhile, the coefficient estimates on *Vintage* both are significantly positive, consistent with the results in Table 5. The coefficient estimates on *Log(Duration)* and *RDINT* are both insignificant different from zero, consistent with the results in Table 5.

[Insert Table 6]

Because firms in High-Tech industries are engaging in more R&D activities, we further investigate whether auditors consider such differences between High-Tech and other industries in the assessment of innovation risk. High-Tech industries include IT computer (SIC codes 3570-3577), software (7370-7379), electronics (3600-3674) and drugs (2833-2836) industries (Francis and Schipper 1999; Baginski, Hassell, and Kimbrough 2004; Banker, Wattal, and Plehn-Dujowich 2011). We first use the patent counts to the proxy for innovation complexity and run the pooled OLS regression to estimate the audit fee model separately for firms in High-Tech industries and other industries.

Table 7 presents the regression results for firms in High-Tech industries in Column (1) and the results for firms in the other industries in Column (3). The coefficient estimates on innovation complexity (*Log(Patent)*) are significantly positive whereas those on patent innovation efficiency (*PEFF*) are significantly negative. The coefficient estimates on the average age of patents, *Vintage*, are significantly postive at the 1% level for both High-Tech firms and firms in other industries. Interestingly, the coefficient estimates on *Log(Duration)* are significantly positive for High-Tech firms but are not significantly different from zero for firms in other industries. The results suggest that auditors do consider the duration of patents to be granted when they assess the risk of innovation activities in High-Tech firms. One explanation is that innovation is one of the key drivers for High-Tech firms to be continuously successful in fast changing markets.

To check the robustness, we also use citation-weighted patent counts (*CPatent*) and market value weighted patent (*VPatent*) to construct the innovation efficiency measure. The untabulated results are consistent with those in Table 7, which means that our research hypotheses are consistent across alternative measures of innovation complexity and efficiency.

[Insert Table 7]

V. ADDITIONAL ANALYSIS

In this section, we examine whether auditors exert more effort to audit the intangible assets of firms that engage in R&D and patenting activities compare to these firms that do not have. To do so, we do not drop the firm year observations with missing patent data or missing prior year R&D expenditures as we did in Section III, and split the sample into four groups: (1) firms that report R&D expenditures and file patents; (2) firms that do not report R&D expenditures but file patents; (3) firms that report R&D expenditures but do not file patents; and (4) firms that do not report R&D expenditures and do not file patents. We treat Group (4) as the base group and construct three dummy variables, *RD_Patent*, *NORD_Patent* and *RD_NOPatent*, to indicate Group (1), Group (2), and Group (3) separately using the definitions of four groups above.

As predicted in the research hypothesis 1, we would expect that given other things equal, the audit fees of group (1) is on average greater than those of groups (2) and (3), and the audit fees of groups (2) and (3) is greater than those of group (4). The regression result of audit fees is presented in Table 8. The coefficient estimates on *RD_NOPatent*, *NORD_Patent*, and *RD_Patent* are 0.233, 0.159, 0.097 and significantly positive. Furthermore, F-test shows that the difference in coefficients on *RD_NOPatent* and *NORD_Patent* is not significant. The difference in coefficients on *RD_Patent* and *RD_NOPatent* is significant at the 1% level, and the difference between *RD_Patent* and *NORD_Patent* is significant at the 10% level. These results support our theory that firms exhibit a higher degree of complexity for investing more in R&D and engaging in patenting activities. Recognizing the higher degree of complexity, auditors rationally exert more effort to audit the innovation results to provide better assurance, leading to higher fees.

VI. CONCLUSION

We find that the three features of corporate innovation, *complexity*, *efficiency* and *obsolescence*, are significantly associated with audit prices. Using a sample of 2,003 firms (9,319 firm-year observations) with patents in fiscal years 2000 to 2010, we find that innovation complexity is significantly associated with higher audit prices, which is consistent with greater audit effort necessary to evaluate numerous management assertions required for intangible assets. Innovation efficiency is associated with superior financial performance (Hirshleifer et al. 2013). We find that innovation efficiency is significantly associated with lower audit fees after controlling for concurrent financial performance. The technological obsolescence, measured by the average

age of a firm's patent portfolio, is positively associated with audit fees, suggesting that auditors take into account risk factors related to useful life and obsolescence status of intangible assets when making pricing decisions. These results are consistent with the findings in prior audit literature that auditors make informed pricing decisions and rationally adjust audit fees based on a variety of client characteristics.

PCAOB inspections have identified deficiencies in auditing management's accounting estimates for intangible and other long-lived assets (PCAOB 2008, 2010, 2015, 2016, 2017). Our results are somewhat comforting in that we find evidence that higher audit prices are associated with higher levels of innovation complexity and technological obsolescence. This suggests that *additional level* of audit effort is devoted to intangible assets (i.e., patents) given their risk characteristics. However, the question is whether or not the level of effort is sufficient is difficult to test empirically.

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Table 1: Definitions of dependent and independent variables

Variables	Descriptions
Log(AF)	= the natural logarithm of (1+*AF*) where *AF* is audit fees;
Log(Patent)	= the natural logarithm of (1+*Patent*) where *Patent* is the number of patents;
Log(TECHCL)	= the natural logarithm of (1+*TECHCL*) where *TECHCL* is the number of technology classes of patents granted based on the U.S. Patent Classification System (USPC);
Log(CPatent)	= the natural logarithm of (1+*CPatent*) where *CPatent* is citation-weighted patents as defined in Kogan et al. (2017);
Log(VPatent)	= the natural logarithm of (1+*VPatent*) where *VPatent* is market value weighted patents as defined in Kogan et al. (2017);
PEFF	= patent innovation efficiency, defined as $Patent_{i,t}/(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6})$ as defined in Hirshleifer et al. (2013), where *Patent* is the number of patents and *R&D* is the R&D expenditure;
CEFF	= citation-weighted innovation efficiency, defined as $CPatent_{i,t}/(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6})$, where *CPatent* is the citation-weighted patents and *R&D* is the R&D expenditure;
VEFF	= market value weighted innovation efficiency, defined as $VPatent_{i,t}/(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6})$, where *VPatent* is the market value weighted patents and *R&D* is the R&D expenditure;
Vintage	= average age of patent portfolio, defined as $\sum_{k=0}^{18}(k+2)*Patent_{it-k}/\sum_{k=0}^{18}Patent_{it-k}$, where *Patent* represents the number of patents granted;
Log(Duration)	= the natural logarithm of *Duration*, where *Duration* is the average length of time between filing and issuance of patents granted;
RDINT	= R&D intensity, defined as the ratio of R&D expenses to sales revenue;
BigN	= 1 if a firm is audited by one of Big 4 auditors, and 0 otherwise;
Size	= the natural logarithm of a firm's total assets;
Log(Segment)	= the natural logarithm of *Segment*, which is the number of business segments;
Foreign	= foreign operations, defined as an indicator variable equal to 1 if foreign exchange gain or loss exceeds $10,000 as in Krishnan and Wang (2015) or pretax foreign income or loss exceeds $10,000, and 0 otherwise;
ROA	= return on assets, defined as income before extraordinary items scaled by total assets;
Loss	= 1 if a firm's ROA is negative, and 0 otherwise;
INVREC	= the ratio of inventories and receivables to total assets;
Quick	= quick ratio, defined as the ratio of current assets less inventories to total current liabilities;
Leverage	= financial leverage, defined as ratio of total debt to total assets;

Concern	= going concern opinions, defined as an indicator variable equal to 1 if a firm received a qualified going concern opinion, and 0 otherwise;
Log(NAF)	= the natural logarithm of (1+*NAF*) where *NAF* is non-audit fees;
December	= 1 if a firm's fiscal year ends in December, and 0 otherwise;
BtM	= the ratio of a firm's book value to its market value;
SGrowth	= the percentage change in net sales from year *t-1* to *t*;
Litigation	= 1 if a firm is in high litigation risk industries (SIC codes 2833-2836, 3570-3577, 3600-3674, 5200-5961, 7370-7374, 8731-8734) defined by Ali and Kallapur (2001);
Log(Age)	= the natural logarithm of *Age*, where *Age* is the number of years that a firm has been publicly listed;

Table 2: Sample selection process

Selection Step	*Number of Observations*
Initial sample drawn from Compustat and Audit Analytics (2000-2010)	122,280
Remove firm year observations of utilities (SIC 4900-4999) and financial institutions (SIC 6000-6999)	(37,498)
Remove firm year observations with missing audit fee data	(28,884)
Remove firm year observations with missing patent data	(44,072)
Remove firm year observations with missing prior year R&D expenses when constructing innovation efficiency measures	(1,212)
Remove firm year observations with missing data on control variables	(1,295)
Final Sample Size	9,319

Table 3: Descriptive statistics of dependent and independent variables

Variables	Mean	Std. Dev.	25th	50th	75th
AF	2,327,718	5,067,855	284,973	757,563	2,061,000
Patent	52.36	242.95	2	5	17
TECHCL	8.73	18.87	1	3	7
CPatent	114.61	517.83	3.75	11.44	40.34
VPatent	534.73	2955.98	2.23	11.43	77.44
BigN	0.890	0.313	1	1	1
PEFF	0.221	0.390	0.042	0.099	0.219
CEFF	0.570	1.178	0.080	0.205	0.502
VEFF	0.753	1.767	0.068	0.212	0.660
Vintage	5.92	3.06	3.44	5.28	7.92
Duration	1,155.2	430.1	847.3	1,080	1,383
RDINT	0.375	0.745	0.035	0.115	0.246
Size	6.181	2.150	4.649	5.973	7.609
Segment	2.602	2.184	1	1	4
Foreign	0.390	0.488	0	0	1
ROA	-0.095	0.321	-0.139	0.020	0.072
Loss	0.426	0.495	0	0	1
RECINV	0.236	0.155	0.114	0.219	0.332
Quick	3.205	3.248	1.253	2.057	3.899
Leverage	0.159	0.194	0.000	0.094	0.257
Concern	0.032	0.177	0	0	0
NAF	1,103,317	3,688,431	45,000	189,000	694,560
December	0.686	0.464	0	1	1
BtM	0.589	0.305	0.353	0.549	0.773
SGrowth	0.200	0.637	-0.047	0.088	0.255
Litigation	0.528	0.499	0	1	1
Age	17.453	10.681	9	14	25

Table 4: Pearson and Spearman Correlation matrix between dependent and independent variables

Variables	*V1*	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*	*V11*	*V12*	*V13*	*V14*
V1:AF	1	0.489	0.518	0.447	0.630	-0.302	-0.292	0.225	0.309	0.187	-0.370	0.255	0.819	0.474
V2: Patent	0.453	1	0.935	0.932	0.824	0.227	0.221	0.528	0.150	0.006	-0.009	0.243	0.577	0.280
V3: TECHCL	0.578	0.836	1	0.865	0.788	0.171	0.161	0.482	0.182	0.002	-0.072	0.236	0.600	0.326
V4: CPatent	0.424	0.983	0.798	1	0.790	0.219	0.338	0.525	0.059	0.039	0.036	0.243	0.530	0.231
V5: VPatent	0.289	0.358	0.375	0.418	1	-0.053	-0.020	0.678	0.170	0.037	-0.078	0.339	0.791	0.308
V6: PEFF	-0.112	0.033	0.014	0.036	-0.043	1	0.921	0.479	-0.116	-0.259	-0.159	-0.185	-0.290	-0.030
V7: CEFF	-0.111	0.011	-0.017	0.029	-0.038	0.854	1	0.485	-0.194	-0.197	-0.087	-0.145	-0.281	-0.076
V8: VEFF	0.065	0.057	0.121	0.081	0.307	0.364	0.386	1	0.022	-0.150	-0.215	0.128	0.383	0.162
V9: Vintage	0.200	0.073	0.136	0.061	0.081	-0.101	-0.145	-0.034	1	0.008	-0.318	-0.006	0.282	0.301
V10: Duration	0.084	0.013	-0.013	0.015	-0.003	-0.151	-0.105	-0.107	-0.012	1	0.178	-0.012	0.039	-0.054
V11: RDINT	-0.158	-0.069	-0.121	-0.069	-0.057	-0.072	-0.054	-0.073	-0.200	0.063	1	0.023	-0.397	-0.480
V12: BigN	0.125	0.066	0.115	0.068	0.063	-0.203	-0.157	0.065	-0.011	-0.023	0.023	1	0.337	0.104
V13: Size	0.618	0.361	0.530	0.355	0.328	-0.223	-0.209	0.218	0.265	0.022	-0.326	0.330	1	0.506
V14: Segment	0.469	0.289	0.421	0.276	0.187	-0.052	-0.082	0.067	0.282	-0.056	-0.277	0.107	0.534	1
V15: Foreign	0.139	0.095	0.121	0.087	0.022	-0.065	-0.069	-0.015	0.091	0.083	-0.207	0.073	0.265	0.163
V16: ROA	0.167	0.083	0.138	0.084	0.093	-0.024	-0.040	0.099	0.220	-0.023	-0.524	0.116	0.462	0.230
V17: Loss	-0.206	-0.084	-0.148	-0.083	-0.105	0.017	0.038	-0.097	-0.256	0.037	0.439	-0.100	-0.431	-0.260
V18: RECINV	0.028	0.002	0.010	-0.006	-0.046	0.132	0.074	-0.049	0.224	-0.188	-0.464	-0.145	-0.031	0.169
V19: Quick	-0.215	-0.090	-0.149	-0.085	-0.071	0.041	0.073	0.036	-0.192	-0.005	0.432	0.010	-0.267	-0.295
V20: Leverage	0.098	0.005	0.034	-0.001	-0.011	-0.017	-0.047	-0.007	0.143	-0.045	0.024	0.042	0.184	0.134
V21: Concern	-0.053	-0.034	-0.057	-0.035	-0.032	0.023	0.009	-0.050	-0.038	0.008	0.133	-0.120	-0.215	-0.065
V22: NAF	0.493	0.381	0.435	0.398	0.413	-0.069	-0.069	0.147	0.153	-0.023	-0.109	0.097	0.439	0.344
V23: December	0.006	-0.059	-0.059	-0.060	-0.003	-0.021	0.008	0.016	-0.055	-0.006	0.141	0.048	-0.002	-0.039
V24: BtM	0.064	0.019	0.031	0.002	-0.101	0.022	-0.032	-0.151	0.063	-0.071	-0.176	-0.030	0.077	0.158
V25: SGrowth	-0.072	-0.043	-0.076	-0.042	-0.026	0.035	0.077	0.104	-0.130	0.006	0.146	0.004	-0.104	-0.110
V26: Litigation	-0.093	0.074	0	0.084	0.064	-0.113	-0.080	-0.033	-0.261	0.167	0.280	0.048	-0.106	-0.250
V27: Age	0.326	0.196	0.290	0.185	0.172	-0.070	-0.127	0.039	0.750	-0.053	-0.278	0.019	0.427	0.414

Variables	*V15*	*V16*	*V17*	*V18*	*V19*	*V20*	*V21*	*V22*	*V23*	*V24*	*V25*	*V26*	*V27*
V1:AF	0.316	0.370	-0.369	0.117	-0.415	0.288	-0.120	0.590	0.009	0.124	-0.038	-0.122	0.412
V2: Patent	0.170	0.207	-0.174	-0.033	-0.121	0.149	-0.097	0.422	-0.014	-0.005	-0.056	0.000	0.230
V3: TECHCL	0.185	0.234	-0.208	0.012	-0.169	0.156	-0.102	0.444	-0.028	0.030	-0.072	-0.021	0.266
V4: CPatent	0.147	0.188	-0.149	-0.071	-0.085	0.081	-0.100	0.410	-0.013	-0.045	-0.028	0.039	0.142
V5: VPatent	0.156	0.344	-0.286	-0.109	-0.134	0.191	-0.166	0.584	0.022	-0.146	0.047	0.023	0.264
V6: PEFF	-0.084	-0.032	0.033	0.167	0.072	-0.078	0.025	-0.202	-0.049	0.023	0.056	-0.175	-0.096
V7: CEFF	-0.087	-0.035	0.047	0.103	0.106	-0.136	0.011	-0.179	-0.047	-0.028	0.074	-0.110	-0.168
V8: VEFF	-0.012	0.296	-0.234	-0.013	-0.015	0.075	-0.129	0.300	0.029	-0.229	0.158	-0.107	0.100
V9: Vintage	0.105	0.260	-0.256	0.251	-0.228	0.212	-0.039	0.186	-0.078	0.100	-0.131	-0.240	0.788
V10: Duration	0.106	-0.023	0.034	-0.206	0.031	-0.083	0.006	-0.050	-0.010	-0.075	-0.004	0.180	0.000
V11: RDINT	-0.170	-0.502	0.507	-0.569	0.523	-0.291	0.097	-0.310	0.068	-0.299	0.042	0.483	-0.415
V12: BigN	0.073	0.106	-0.100	-0.116	0.007	0.070	-0.120	0.337	0.048	-0.012	0.038	0.048	-0.014
V13: Size	0.275	0.469	-0.444	0.033	-0.350	0.351	-0.208	0.719	-0.010	0.132	-0.008	-0.112	0.402
V14: Segment	0.175	0.256	-0.283	0.268	-0.405	0.266	-0.071	0.426	-0.050	0.239	-0.089	-0.280	0.412
V15: Foreign	1	0.178	-0.174	0.163	-0.162	0.088	-0.059	0.187	-0.010	0.129	-0.028	-0.077	0.132
V16: ROA	0.190	1	-0.857	0.284	-0.127	-0.018	-0.239	0.314	-0.070	-0.141	0.178	-0.182	0.333
V17: Loss	-0.174	-0.614	1	-0.277	0.179	-0.038	0.187	-0.312	0.065	0.046	-0.149	0.204	-0.330
V18: RECINV	0.136	0.210	-0.239	1	-0.460	0.116	-0.007	0.098	-0.113	0.203	-0.044	-0.409	0.300
V19: Quick	-0.187	-0.073	0.203	-0.435	1	-0.484	-0.129	-0.354	-0.009	-0.217	0.082	0.294	-0.309
V20: Leverage	0.039	-0.108	0.051	0.012	-0.233	1	0.054	0.285	0.076	0.162	-0.051	-0.214	0.243
V21: Concern	-0.059	-0.378	0.187	0.012	-0.082	0.099	1	-0.121	0.033	-0.003	-0.074	0.000	-0.049
V22: NAF	0.074	0.109	-0.136	0.014	-0.151	0.080	-0.046	1	-0.030	0.086	-0.030	-0.140	0.296
V23: December	-0.010	-0.078	0.065	-0.115	0.032	0.081	0.033	0.021	1	-0.079	0.064	-0.008	-0.137
V24: BtM	0.099	0.019	0.094	0.182	-0.085	0.039	0.012	0.002	-0.072	1	-0.294	-0.158	0.151
V25: SGrowth	-0.086	-0.068	0.054	-0.123	0.110	-0.016	-0.014	-0.045	0.078	-0.197	1	0.029	-0.154
V26: Litigation	-0.077	-0.151	0.204	-0.374	0.229	-0.131	0.000	-0.046	-0.008	-0.131	0.058	1	-0.243
V27: Age	0.120	0.285	-0.335	0.262	-0.266	0.150	-0.057	0.222	-0.112	0.109	-0.154	-0.270	1

The lower triangle matrix presents Pearson correlation coefficients between the dependent variable and variables of interest, and the upper triangle matrix presents Spearman correlation coefficients. *AF*, *Patent*, *TECHCL*, *CPatent*, *VPatent*, and *Duration* are raw (non-transformed) data defined in Table 1.

Table 5: OLS regression results of innovation and auditor fees

VARIABLES		Pred. Sign	Dependent Variable: *Log(AF)*			
			(1) Coefficients	(2) t-statistics	(3) Coefficients	(4) t-statistics
Log(Patent)	H1	+	0.061***	3.811		
Log(TECHCL)	H1	+			0.110***	5.077
PEFF	H2	-	-0.231***	-3.987	-0.227***	-3.845
Vintage	H3	?	0.029***	5.211	0.029***	5.210
Log(Duration)			0.060	0.778	0.056	0.723
RDINT			-0.028	-1.271	-0.028	-1.235
BigN			0.229***	2.966	0.230***	2.994
Size			0.473***	18.730	0.469***	19.958
Log(Segment)			0.115***	4.883	0.109***	4.639
Foreign			0.039	1.381	0.039	1.379
ROA			-0.322***	-3.823	-0.314***	-3.809
Loss			0.048	1.139	0.049	1.177
INVREC			0.468***	3.915	0.465***	3.902
Quick			-0.040***	-5.788	-0.039***	-5.761
LEV			0.032	0.499	0.041	0.632
Concern			0.100	1.495	0.100	1.473
Log(NAF)			0.025*	1.953	0.025*	1.950
December			0.156**	1.967	0.157**	1.984
BtM			-0.112**	-2.278	-0.112**	-2.353
SGrowth			-0.009	-0.552	-0.007	-0.466
Litigation			-0.070	-1.350	-0.061	-1.190
Log(Age)			-0.088**	-2.260	-0.089**	-2.286
Industry fixed effect			Included		Included	
Year fixed effect			Included		Included	
Constant			8.779***	14.950	8.778***	14.833
Observations			9,319		9,319	
Adj. R-squared			0.656		0.657	

Standard error are two-way clustered by firm and year and t-statistics are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 6: OLS regression results when considering the quality of innovation

VARIABLES		Pred. Sign	Dependent Variable: *Log(AF)*			
			(1) Coefficients	(2) t-statistics	(3) Coefficients	(4) t-statistics
Log(CPatent)	H1	+	0.052***	3.573		
Log(VPatent)	H1	+			0.051***	3.883
CEFF	H2	-	-0.061***	-3.365		
VEFF	H2	-			-0.045***	-5.526
Vintage	H3	?	0.030***	5.243	0.029***	5.040
Log(Duration)			0.065	0.840	0.072	0.933
RDINT			-0.023	-1.048	-0.016	-0.695
BigN			0.238***	3.036	0.249***	3.152
Size			0.479***	19.050	0.476***	18.493
Log(Segment)			0.115***	4.856	0.117***	4.902
Foreign			0.038	1.322	0.045	1.607
ROA			-0.327***	-3.905	-0.326***	-3.982
Loss			0.052	1.219	0.062	1.489
INVREC			0.473***	3.854	0.467***	3.844
Quick			-0.039***	-5.774	-0.040***	-5.881
LEV			0.027	0.418	0.008	0.122
Concern			0.103	1.546	0.118*	1.770
Log(NAF)			0.025*	1.956	0.025*	1.953
December			0.159**	2.004	0.151*	1.921
BtM			-0.113**	-2.215	-0.097**	-2.036
SGrowth			-0.007	-0.464	-0.006	-0.424
Litigation			-0.066	-1.279	-0.070	-1.343
Log(Age)			-0.087**	-2.179	-0.085**	-2.266
Industry fixed effect			Included		Included	
Year fixed effect			Included		Included	
Constant			8.662***	14.658	8.628***	14.366
Observations			9,319		9,319	
Adj. R-squared			0.658		0.658	

Standard error are two-way clustered by firm and year and t-statistics are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: OLS regression results of subsample analysis using number of patent as the innovation measure

VARIABLES		Pred. Sign	Dependent Variable: *Log(AF)*			
			High-Tech firms		Other firms	
			(1) Coefficients	(2) t-statistics	(3) Coefficients	(4) t-statistics
Log(Patent)	H1	+	0.046**	2.350	0.076***	3.962
PEFF	H2	-	-0.206**	-2.236	-0.266**	-2.413
Vintage	H3	?	0.020**	2.044	0.028***	4.021
Log(Duration)			0.203**	2.271	0.018	0.171
RDINT			-0.064**	-2.307	0.000	0.006
BigN			0.170**	2.207	0.244**	2.267
Size			0.433***	13.984	0.503***	26.622
Log(Segment)			0.136***	4.411	0.083***	2.826
Foreign			0.028	0.640	0.090**	2.499
ROA			-0.262**	-2.262	-0.414***	-4.043
Loss			0.036	0.710	0.054	0.909
INVREC			0.523***	3.679	0.357**	2.120
Quick			-0.043***	-4.693	-0.036***	-3.307
LEV			-0.139	-1.629	0.164	1.496
Concern			0.038	0.276	0.111	0.820
Log(NAF)			0.031*	1.674	0.021**	2.512
December			0.072	0.886	0.202**	2.157
BtM			-0.052	-0.734	-0.258***	-3.995
SGrowth			-0.015	-0.854	-0.017	-0.606
Log(Age)			-0.072	-1.223	-0.073*	-1.666
Industry fixed effect			Included		Included	
Year fixed effect			Included		Included	
Constant			7.924***	10.483	8.947***	11.200
Observations			4,838		4,481	
Adj. R-squared			0.626		0.683	

Table 8: Regression result of audit fees for four subsamples

VARIABLES	Pred. Sign	Dependent Variable: *Log(AF)*	
		(1) Coefficients	(2) t-statistics
RD_NOPatent	+	0.097**	2.012
NORD_Patent	+	0.159***	3.262
RD_Patent	+	0.233***	5.295
BigN		0.347***	12.712
Size		0.471***	22.873
Log(Segment)		0.119***	8.036
Foreign		0.163***	8.747
ROA		-0.090***	-10.463
Loss		0.177***	10.481
INVREC		0.220***	3.282
Quick		-0.021***	-5.666
LEV		-0.037	-1.473
Concern		0.106	1.465
Log(NAF)		0.038***	2.644
December		0.131**	2.364
BtM		-0.216***	-3.513
SGrowth		-0.040***	-5.441
Litigation		0.013	0.538
Log(Age)		0.002	0.176
Industry fixed effect		Included	
Year fixed effect		Included	
Constant		8.775***	51.934
Observations		41,597	
Adj. R-squared		0.568	

Standard error are two-way clustered by firm and year and t-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1