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Knowledge Commercialization and University Audit Fees: A UK-Based Study

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ABSTRACT

In the face of stiffening sector competition and reduced government funding, universities in many countries increasingly seek to diversify their revenue. One prominent way employed by universities to achieve revenue diversification is the commercialization of research knowledge. However, knowledge commercialization could be regarded as a risky enterprise for many institutions, especially those lacking the capacity to support commercial activity. To investigate these issues, we examine the impact of knowledge commercialization on the audit fees charged to UK universities. Using a panel dataset covering 2010/11–2019/20, we find that knowledge commercialization is positively associated with university audit fees, indicating that auditors may charge more to compensate for the greater workloads and risks associated with auditing universities with more commercial activity. Further analysis shows that the positive commercialization–fees relationship is weaker in universities that spend more on research and science, technology, engineering, and mathematics (STEM) subjects, suggesting that auditors perceive knowledge commercialization activities as carrying lower risk if the university has more capacity for undertaking research that can be commercialized. We conclude by discussing the implications of what we identify as a growing divergence among universities in their ability to commercialize research knowledge as perceived by auditors.

1 | Introduction

In addition to their traditional functions of providing teaching and conducting research, universities are increasingly involved with a third mission, which refers to efforts to contribute to society by commercializing knowledge and engaging with external actors (Compagnucci and Spigarelli 2020; Pinheiro et al. 2015). Within this setting, knowledge commercialization, defined by Universities UK as the "process by which universities turn… research into products and services" (Castell 2023), has become an especially important component of the third mission. The commercialization of research was pioneered by US universities during the 1980s (Mowery et al. 2004) and has been galvanized by governmental organizations across many jurisdictions (e.g., Carrion and Carot 2012; RSM 2018). As a result, universities have been rolling out entrepreneurial activities, such as patenting and licensing, building science parks, and investing equity in start-ups (Mariani et al. 2018; Siegel 2006). In this article, we investigate the impact on the external audit of universities undertaking knowledge commercialization activities. The requirement of undertaking an external audit is key to enabling financial accountability and control, and the intensity of that audit, measured as the fees paid by a university to its auditor, can reveal important information on how auditors perceive the financial risks associated with research commercialization and universities' capacity for mitigating risks involved with those activities.

Following the seminal work by Simunic (1980), a large body of research has emerged seeking to explain the determinants of audit fees. As research has predominantly focused on the private sector (Hay 2013), we have limited knowledge on the determinants of audit fees in the public and non-profit sectors. This knowledge gap encompasses universities, which in many countries, such as the United Kingdom (UK), are organizations that are sometimes considered part of the public sector due to the high level of political authority to which they are subject, especially in terms of their funding from and control by government (see Bozeman 2004). In contrast to slightly more developed audit research strands in relation to other non-profit sector entities, such as local governments and hospitals (Clatworthy et al. 2008; De Widt et al. 2022; Giroux and Jones 2007), only two studies have looked at audit pricing for UK universities. A study by Mellett et al. (2007) draws on data from 2001, whereas the most recent study by Xue and O'Sullivan (2013) draws on data from 2007 to 2010. Furthermore, both private and public sector studies have largely ignored the role of knowledge commercialization in relation to audit pricing, with few private-sector exceptions such as Datta et al. (2020) and Visvanathan (2017).

In the period since 2010, UK universities have undergone many changes, including large reductions in central government funding and the removal of limits previously in place on the number of students universities are allowed to admit (though not in Scotland) (Carasso 2023). These reforms have resulted in greater reliance by universities on (international) tuition fees, stiffened sector competition, incentivized universities to seek new funding sources for capital investment (e.g., bond issuing), and to diversify revenue income including through research commercialization (McCann et al. 2019). In this article, we seek to examine whether knowledge commercialization is associated with a heightened perception of financial risk as measured by the additional work reflected in higher audit fees. In addition, we develop arguments about the benefits of research capacity for perceptions of financial risk, especially in terms of how high-capacity institutions may be perceived to have a lower risk level when undertaking knowledge commercialization activities.

Our article makes several contributions. First, we contribute to the international audit literature, where there has been little attention to the determinants of audit pricing in the higher education sector. Second, we address the impact of commercialization on universities' audit costs. Given that universities in many countries operate in an increasingly commercialized environment and face pressure to diversify revenue, evidence of the implications of commercialization for financial accountability and control is both timely and relevant (Exworthy and Lafond 2021; Hay and Cordery 2018; Parker 2024). Third, utilizing a longitudinal dataset, our article provides novel insights as to how commercialization impacts differently upon the audit fees charged to universities depending on their research capacity, thereby reflecting a divergence amongst universities in their ability, as perceived by auditors, to successfully commercialize research knowledge. The remainder of the article is structured as follows: we first review the relevant literature, followed in Section 3 by a discussion of the institutional and audit features of UK universities. Section 4 subsequently presents the data and research design; Section 5 presents the empirical results, including tests to ensure the robustness of results; and Section 6 concludes.

2 | Literature Review

In many countries, universities have sought to diversify their revenue in recent years, with the commercialization of university-produced research knowledge constituting a key strategy (Perkmann et al. 2013). Universities employ many different modes for commercializing research knowledge, but the most significant include patenting of research innovations, the subsequent levying of revenues resulting from intellectual capital (IC) rights, and setting up vehicles for commercializing knowledge, such as spin-offs and subsidiaries (D'Este and Patel 2007; Hewitt-Dundas 2012). In the United States, the Bayh–Dole Act of 1980 was a pioneering step in university research commercialization as it encouraged universities to use patent systems to promote the utilization of university inventions from federally supported research (Perkmann et al. 2013). Although few countries have introduced as encompassing legislation as the US Bayh–Dole Act, many countries now have frameworks in place to support the commercialization of university-produced research knowledge, which, in the UK, was significantly incentivized with the introduction, in 1999, of "third-stream" government funding for knowledge transfer by universities (Clough and Bagley 2012).

Following this trend, intangible assets, which are non-physical assets, such as patents, inventions, software, data, and technical information, make up a growing proportion of university assets. An increasing number of studies investigate the relationship between universities and IC, such as how universities manage or disclose their IC and commercialization activities (Córcoles and Ponce 2013; Iacoviello et al. 2019). Drawing on insights from the resource-based theory of the firm, much of this research suggests that universities with strong capacities in funded research and science, technology, engineering, and mathematics (STEM) subjects engage in more knowledge commercialization (e.g., O'Shea et al. 2005; Powers and McDougall 2005; Rodeiro Pazos et al. 2012; for a review, see Lee and Jung 2024). To the best of our knowledge, however, no studies exist investigating how knowledge commercialization affects audit pricing for universities.

The increasing effort by universities across the globe to commercialize their often highly developed IC base (Cricelli et al. 2018; Mariani et al. 2018) raises important questions about the potential risks that this can pose to management and governance in the higher education sector (Caulfield and Ogbogu 2015). Nevertheless, surprisingly little academic research has addressed the financial risks associated with knowledge commercialization or what organizational characteristics might mitigate those risks (RSM 2018). In particular, almost nothing is known about the audit fees paid by universities, which represent an important indicator of the level of effort required to provide assurance that the financial sustainability of institutions is being safeguarded, especially whether funds (including public funds) have been applied for the intended purposes (Office for Students 2018, 29). To develop testable hypotheses on the connection between knowledge commercialization and audit fees, we, therefore, draw upon the extant literature on IC and audit fees in the private sector and integrate that with a resource-based perspective on the role that university research capacity might play in shaping auditors' perceptions of financial risk in universities.

2.1 | Hypotheses

In relation to the private sector, a small but growing literature highlights the impact of IC on audit fees charged to private sector firms, such as Datta et al. (2020), who find that firms with a greater likelihood of innovation success, as expressed by their number of patents, are charged higher audit fees. The authors explain this by referring to the greater difficulty for auditors to value and collateralize intangible assets, resulting in extra effort and litigation risk faced by auditors, subsequently increasing the audit fee. Other private sector–focused studies similarly trace a positive relationship between IC and audit fees, with scholars similarly pointing at the greater audit effort required due to managerial manipulation posing a particular risk to the valuation and recording of IP-related assets and activities (Dashtbayaz et al. 2023; Visvanathan 2017).

It can be expected that the impact of IC on the external audit for an organization operating in the private versus the public sector will have similarities, as in both cases the auditor's workload will increase, for example, in verifying the organization's financial statements and supporting organizations in assessing and managing risks in relation to IC. However, auditing IC revenue generation in the case of public and nonprofit organizations such as universities also likely requires auditors to consider sector-specific features. First, research commercialization is a relatively minor and new activity for some universities, resulting in those universities having limited familiarity with the commercial aspects associated with IC revenue generation. This includes negotiating spin-out term sheets—that is, the division of equity stakes between the university, spin-off founders, and investors—which is a challenging process for many universities as they often seek equity shares that are perceived to be too large by investors, thereby reducing the chance of the spin-off receiving investment (Hellmann et al. 2023). In some cases, universities that initially aim for a large equity stake concede on more market competitive terms, but only after a lengthy negotiation process, which adds to the costs universities imburse to commercialize their research. Second, university translational and proof-of-concept funding for spin-offs is often taken by committees of academics who meet infrequently and may lack experience or knowledge to evaluate which research projects have genuine commercial potential (Tracey and Williamson 2023).

A third factor relates to the role of university technology transfer offices (TTOs), which include university staff who work with academics to analyze the commercial potential of research and decide whether to formally protect IP through a patent at the university's expense and, if so, whether to subsequently license the IP to an existing company for a fee or use it as the basis for a spin-off. Although TTOs play a critical role in successfully commercializing research, universities vary greatly in the capacity and expertise of these offices (Siegel et al. 2003). In the United Kingdom, TTOs in some universities may have only one or two staff responsible for licensing with less than one spin-off per year, resulting in staff holding less sector-specific expertise and less stream-lined spin-off processes (Tracey and Williamson 2023). Consequently, many universities are not making substantial profits on research commercialization activities, and some even experience losses. From an auditor's perspective, the risks associated with IC-related activities may be perceived as more substantial when undertaken by universities, as they are less familiar with commercial environments than private sector businesses, whereas capabilities to successfully commercialize research also diverge strongly between universities. Previous studies on the pricing of university audits by Mellett et al. (2007) and Xue and O'Sullivan (2013) do not include variables in relation to IC, such as patents, spin-offs, and IP revenues, which might reflect the lesser importance of IC in contributing to universities' income during the pre-2010 period. In recent years, however, British universities have expanded their knowledge commercialization activities, increasing their income deriving from intellectual property rights. For the UK university sector as a whole, IC revenues grew from around £69 million (mn) in 2010 to £295 mn in 2019/20 (Higher Education Statistics Agency [HESA] data). British universities have also substantially increased their creation of spin-offs, reflected in a 36% increase of university-owned active firms between 2010 and 2019 (from 1045 to 1422, HESA data). Many university-generated firms have been sold to national and international investors, with annual equity investment in UK university spin-offs having increased from £0.55 bn in 2011 to £1.24 bn in 2019 (Beauhurst 2020).

Although knowledge commercialization vehicles such as patents and spin-offs may increase university revenue, features of these vehicles likely result in a more complex and time-consuming audit, leading to higher audit fees. As compared with tuition fees and government funding, revenues from knowledge commercialization might be unstable due to the highly uncertain and volatile demand for knowledge-based products and services (Hearn et al. 2004). Many spin-offs have a lifespan of only a couple of years, as they may either fail or, if successful, be acquired by an external investor. Further contributing to a high turnover of these entities is that universities prefer to focus on creating new spin-offs rather than extending collaboration with existing firms (Rasmussen et al. 2006). Moreover, as has been identified for the private sector, from an audit perspective, intangible assets such as university-generated patents come with increased risks in terms of valuation as, unlike tangible assets, active and open markets often do not exist for intangible assets, thereby increasing audit risk.

On the basis of the above arguments, we expect that the auditors of universities with more IC-related activities, as reflected by patents, spin-off activities, and IC revenues, will associate a greater level of financial risk with these universities, subsequently resulting in a more time-consuming audit. Consequently, we test the following hypothesis:

Hypothesis 1. *Knowledge commercialization is positively associated with university audit fees.*

Knowledge commercialization activities will affect university audit fees; however, the organizational characteristics of universities may be relevant too. The resource-based view of the firm highlights the role that distinctive tangible and intangible resources can play in embedding the capacity required to achieve organizational goals (Barney 1991). Within the higher education sector, universities that devote more resources to STEM subjects tend to have greater research capacity and are able to attract

substantial nontuition fee income, such as research grants. These universities also tend to be more successful in attracting high fee-paying international students, which have become an increasingly important revenue source for universities given that tuition fees for domestic students have remained largely unchanged since they were raised to £9000 per year in 2012 (a small increase to £9250 p/y was implemented in 2017). Consequently, more research-intensive universities tend to have a more resilient and diverse revenue structure, such as funding deriving from various research funding bodies, compared to more teaching-focused universities (Bell et al. 2022). Drawing on findings of audit studies outside the university sector (Hay 2013), a more diversified and resilient income structure of universities with greater research capacity, that is, universities with more research income and greater focus on STEM subjects, is likely to reduce financial and other risk exposure of universities as perceived by auditors, subsequently reducing required audit effort. Hence, the following hypothesis will be investigated:

Hypothesis 2. *Research capacity is negatively associated with university audit fees.*

Although we expect knowledge commercialization to increase university audit fees, studies based on the resource-based view of the firm highlight dissimilar capacities among universities when executing knowledge commercialization activities, such as the creation of spin-off companies (Lee and Jung 2024). These different capacities partly follow from differences in human capital resources, as access to expert knowledge and talent has been identified as key for the development of cutting-edge technologies that often form the backbone of successful commercialization activities (Powers and McDougall 2005). Zucker et al. (1998), for example, state that "star" scientists from highly ranked universities have greater motivation to start spin-off companies in order to profit from the IC they have created. As knowledge that generates IC is tacit and often based in small informal networks among academics based in highly ranked universities, at least initially, it is challenging for academics based in lesser quality universities to replicate this knowledge (O'Shea et al. 2005).

Relatedly, the relationship between university research performance and commercialization has been found to be largely positive (Perkmann et al. 2013; Sengupta and Ray 2017). In the UK, this is reflected in universities with higher research quality having been found to be more successful in undertaking commercialization activities compared to universities with lower research performance (Hewitt-Dundas 2012). Universities with greater research capacity will have a more expansive and heterogeneous resource base to draw on when seeking to commercialize research knowledge, which results in a higher frequency of successful spin-offs and other commercial activities. This reduces financial risks that may arise for universities relying on a single or small number of knowledge-based commercial entities or inventions. Further, universities with greater research capacity will be better resourced to transition research knowledge to income-generating commercialization output by having more advanced infrastructure and greater expertise. Research-intensive universities are likely to have better equipped TTOs and staff (Miranda et al. 2021), which are crucial in maximizing knowledge commercialization through activities such as patenting and supporting start-ups (Hsu et al. 2015; Siegel et al. 2003).[1] Boardman and Ponomariov (2009) find that scientists associated with research-centered universities are more likely to interact with the private sector through patenting and other forms of commercial interaction, while Bozeman and Gaughan (2007) show that academic researchers with research grants have greater capacity to work with industry than those without grants. Furthermore, Hewitt-Dundas (2012) suggests that research-intensive universities have comparative advantages not only in developing knowledge products but also in protecting revenues from their IP. Hence, it can be expected that universities with greater research capacity and expertise in commercializing research knowledge will be better equipped to optimize revenue and mitigate financial risks linked to commercialization activities.

On the basis of these insights, we expect that the audit fee-enhancing impact of knowledge commercialization will decline with an increase in a university's research capacity as auditors are likely to perceive universities with greater research capacity as better equipped to undertake commercialization activities and protect their commercialization output, thereby reducing auditor concerns and required audit effort. Consequently, the following hypothesis has been formulated:

Hypothesis 3. *The positive relationship between commercialization and university audit fees diminishes with an increase in university's research capacity.*

3 | Institutional Context and Audit Framework

Universities in the UK are autonomous institutions with a high degree of financial and academic independence. In our analysis, we concentrate on all universities that provide undergraduate and postgraduate courses and return data to the UK HESA. Consequently, all 24 members of the Russell Group that together receive two-thirds of the research grant and contract funding in the UK, as well as another 102 public universities, are included in our sample.[2] Although UK universities are autonomous, various regulatory bodies monitor their performance. Most important in England is the Office for Students (OfS), which sits within the Department for Education, with similar bodies existing in the other UK countries.[3] Universities in England wishing to access public funding must register with the OfS or its devolved counterparts, pay a registration fee, and submit to the associated regulatory framework. Regulators have been criticized for not closely monitoring the finances of higher education institutions, which have become increasingly fraught, for example, reflected in the number of UK higher education institutions with an in-year deficit rising from seven (5%) in 2015/16 to 80 (32%) in 2019/20 (NAO 2022).

In terms of risk, UK universities operate in a competitive environment, especially for the recruitment of high-fee-paying international students, who have become increasingly important to mitigate university cost pressures, including those caused by inflation. Competition among UK universities has been further intensified following Brexit and the UK government's stricter migration policies, which has caused additional challenges for universities, including the ability to attract top academic talent and address the growing appeal of rival markets such as Canada (Foster and Borrett 2024). In light of heightening challenges,

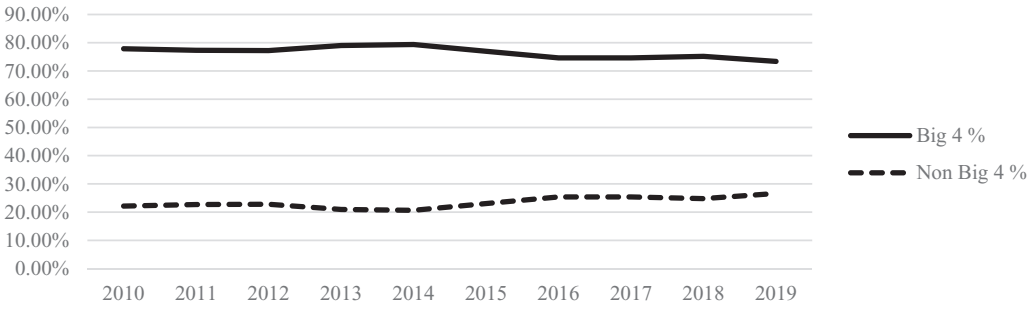

FIGURE 1 | Market share of UK universities audited by Big 4 and non-Big 4 firms. *Source:* Own composition, using university financial statements.

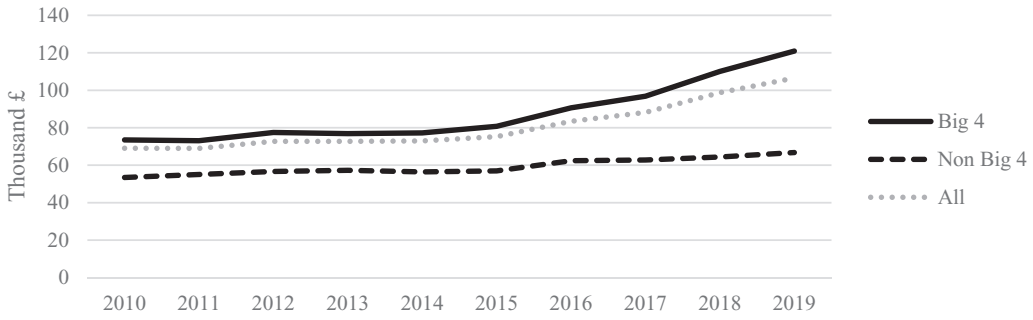

FIGURE 2 | Average audit fees of UK universities charged by Big 4, non-Big 4, and all firms. *Source:* Own composition, using university financial statements.

growing emphasis has been placed on the financial self-reliance of UK universities. This is reflected in credit rating agencies emphasizing the "intrinsic strength" of a university's finances andits position in national and international rankings (Hale 2018). Yet qualitative judgment on whether the government would allow universities to go bankrupt remains important, and anecdotal evidence suggests that the government's policy of permitting "market exit" is perceived by some stakeholders as being more relevant to newer, financially weaker universities than more "established" institutions such as the Russell Group universities (Matthews 2018).

UK universities are subject to regular financial audits, typically on an annual basis, to ensure compliance with financial regulations and standards. Universities in England have to report on their finances to the OfS, those in Northern Ireland to the Department for the Economy, those in Scotland to the Scottish Funding Council, and, in Wales, to the Higher Education Funding Council for Wales. The majority of universities, around three-quarters, are audited by Big 4 firms (Figure 1). Among the Big 4, KPMG maintained the largest market share during the period 2010–19, with around half of all Big 4 audited universities audited by KPMG (e.g., 56% in 2019). In line with previous studies, the average audit fees charged to universities by Big 4 firms are significantly higher compared to non-Big 4 firms, with the average audit fee charged by Big 4 firms having increased more in recent years compared to non-Big 4 firms (Figure 2). However, it is important to highlight that Big 4 firms tend to focus on auditing larger universities, whereas the audit assignments of non-Big 4 firms are more often located at small universities. When we consider size differences between universities by expressing audit fees as a percentage of a university's total income, the audit fees charged by Big 4 firms are, in fact, lower than those charged by non-Big 4 firms. During the period from 2010 to 2019, average audit fees were equivalent to 0.04% of a university's total income for Big 4 audits, versus 0.06% for non-Big 4 audits. Hence, increases in audit fees since 2010 correspond with increases in universities' overall income, which itself is linked to a rise in student numbers, especially high-fee-paying international postgraduate students. Figure 3 shows that when considering university income rises, audit fees charged by Big 4 firms have remained fairly stable since 2010, although there was an uptick in 2018. In contrast, average audit fees charged by non-Big 4 firms have been more volatile, including a reduction between 2013 and 2016, possibly reflecting a more competitive playing field among non-Big 4 firms.

Financial management in UK universities is generally considered to be of high standard, with frequent knowledge exchange taking place between universities on their financial operations, for example, via the British Universities Finance Directors Group (BUFDG). The sector's prudent governance and financial management is reflected by auditors rarely issuing qualified audit opinions, with the issuing of a qualified audit opinion in relation to the 2017/18 financial statements of Swansea University in Wales being an atypical case (Lewis 2019). Although UK universities have traditionally applied a conservative financing approach, this has seen changes following the surge in their capital spending over the past decade, which has been mostly financed through borrowing, reflected by the tripling of universities' long-term debt between 2010 and 2020 (from £4.8 billion (bn) to £13.7 bn, HESA data).

As shown in Figure 4, UK universities have become increasingly engaged in commercial activities, which have been instigated by a need to diversify university revenue, but other factors matter too, such as the main research assessment framework (REF) in place

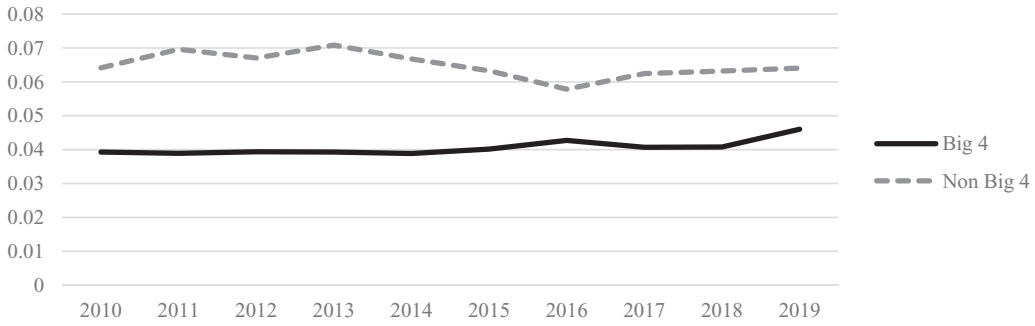

FIGURE 3 | Average fees-to-income ratio (%) of Big 4 and non-Big 4 firms, 2010–2019. *Source:* Own composition, using university financial statements.

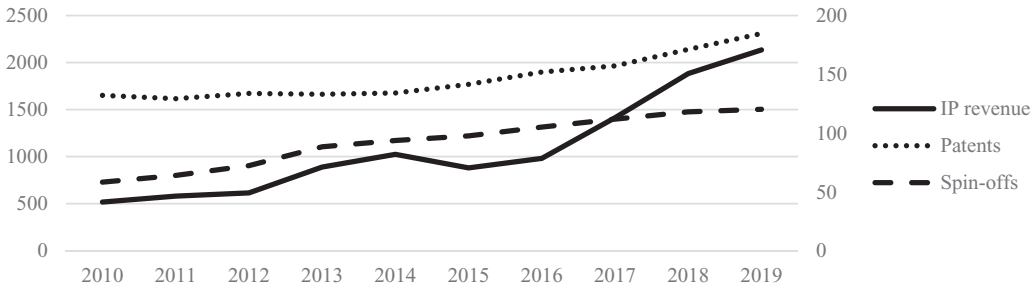

FIGURE 4 | Average commercialization performance, 2010–2019. Left-side axis: Average IP revenue income per university (in £1,000). Right-side axis: Average number of newly registered patents and total spin-offs per university. *Source:* Own composition, using HESA statistics.

in the UK, which emphasizes impact, with commercialization used as a key avenue to demonstrate research impact (RSM 2018). University commercialization in general encompasses a broad range of activities, not all of which are knowledge-based, such as university accommodation letting or catering. For many universities, however, knowledge commercialization is the primary generator of commercial revenue, which may derive from activities including consultancy services, contract research, professional development education, and startups and spin-offs. As part of universities' strategy to enhance income from knowledge commercialization, they have made significant investments in their estates in order to develop an attractive entrepreneurial infrastructure (e.g., capital expenditure in 2019 was £4.2 bn, HESA statistics).

Many universities have successfully expanded the number and lifespan of their spin-offs, which is reflected in a 36% increase in the total number of university-owned spin-offs between 2010/11 and 2019/20 (from 1045 to 1422) and an increase in staff employed by these organizations from 7356 in 2010/11 to 20,597 in 2019/20 (HESA data). The growth of these commercial entities has been aided by universities being able to offer affordable office space and easy access to talented staff and capital, the latter facilitated by substantial domestic and, increasingly, international equity investment in academic spin-offs. Many university spin-offs are linked to the life sciences sector, such as pharmaceuticals and biotech, alongside sectors such as manufacturing technologies and artificial intelligence (Beauhurst 2023). Although significant differences exist between British universities, factors identified as positively influencing universities' engagement with commercialization include the skills and resources available within the university for undertaking commercialization, in particular their TTOs, support from university central leadership and management, and the presence of specific policies that encourage academics to engage with commercialization (e.g., through university career structures). These factors are perceived to be stronger in more research-oriented universities, as suggested by various stakeholder surveys in relation to research commercialization undertaken among the university, business, and investment sectors (RSM 2018; Tracey and Williamson 2023).

4 | Research Design

4.1 | Sample Selection and Data

This study collects data from 126 UK universities, including 100 from England, 15 from Scotland, 8 from Wales, and 3 from Northern Ireland. Our dataset covers the financial years from 2010/2011 to 2019/2020. Data for audit fees, audit firms, and bond issuance have been hand-collected from universities' financial statements. For the commercialization variables and other independent variables, data are retrieved from HESA. Details of the variables and data sources are given in Table 1.

4.2 | Variables

4.2.1 | Dependent Variable and Key Independent Variables

In line with previous studies, the audit fees charged by the university's external auditor are our dependent variable, with the natural logarithm of the measure included in the statistical

TABLE 1 | Variables, descriptions, and data sources.

Variables	Label	Description	Data source
Audit fees	Lnauditfees	Natural log of audit fees	Financial statements
Number of patents	Patents	Number of cumulative patent portfolio	HESA
Number of active spin-offs	Spinoffs	Number of active spin-offs, including spin-offs with some HEP ownership, formal spin-offs not HEP owned, staff start-ups, and graduate start-ups.	HESA
IP revenues	Lniprev	Natural log of total intellectual property income (including patents, copyright, design, registration, and trademarks)	HESA
Research grants (%)	Researchr	Ratio of research grants to total income	HESA
STEM expenditure (%)	Stemexpr	Ratio of STEM discipline expenditure to total expenditure	HESA
Total assets	Lntlta	Natural log of total assets	HESA
Number of students	Lnstudent	Natural log of total students	HESA
Capital expenditure	Lncapexp	Natural log of capital expenditure	HESA
Tuition fee (%)	Tuitionr	Ratio of tuition fees to total income	HESA
International tuition fee %	Int-tuitionr	Ratio of international tuition fees (non-UK & non-EU) to total income	HESA
Endowment income (%)	Endowr	Ratio of endowment, donation, and investment income to total income	HESA
Leverage (%)	Leverage	Ratio of total debts to total assets	HESA
Deficit(surplus)-to-asset (%)	Defsur	Deficit(surplus)-to-asset ratio	HESA
Bond issuance	Bond	Binary variable that equals 1 if the university issues bonds, 0 otherwise	Financial statements
Vice-chancellor gender	Vcgender	Binary variable that equals 1 if the vice-chancellor of a university is male, 0 otherwise	Financial statements
Vice-chancellor years in office	Vcyear	Vice-chancellor's years in office	Financial statements
Big 4 auditors	Bigfour	Binary variable that equals 1 for a Big 4 audit firm, 0 otherwise	Financial statements
Non-audit fees	Lnnonaudit	Natural log of fees charged by auditors for non-audit services	Financial statements
Period 2016–2019	yr2016	Binary variable that equals 1 for 2016–2019, 0 otherwise	

Abbreviations: STEM, science, technology, engineering, and mathematics; HESA, Higher Education Statistics Agency.

modeling. Following previous studies (e.g., Hearn et al. 2004; Perkmann et al. 2013; Rasmussen et al. 2006; Sengupta and Ray 2017), we gauge a university's engagement in knowledge commercialization using three measures that we believe capture the most relevant aspects of commercialization: (1) a university's number of cumulative patents[4]; (2) the number of active spin-offs, which includes entities such as staff start-ups; and (3) a university's IP revenue (in a natural logarithm form, *lniprev*). Patents and spin-offs are two major vehicles for knowledge commercialization, indicating the extent to which universities seek to create formal structures, whereas IP revenues have been used in previous studies to measure the outputs from patenting, spin-offs, and other related activities (D'Este and Patel 2007; Hewitt-Dundas 2012; Sengupta and Ray 2017). Universities vary considerably in their preferences for different types of knowledge commercialization, so each indicator provides a valuable alternative perspective on commercial activity.

We measure research capacity using two indicators. The first one *researchr* is the ratio of research grants to the total revenue of a university, representing the extent to which a university relies on research funding compared with other sources of revenue. Universities with higher research grant capture are more likely to generate large revenue from commercialization activities (Rasmussen et al. 2006). Thus, a higher value proxies for greater research capacity. The second one *stemr* is the ratio of research expenditure for STEM disciplines to the total research expenditure.[5] Researchers have argued that universities with better capacity in STEM research are more likely to produce high-quality patents (Saxenian 1994). Further, STEM-related patents tend to be more abstract and codifiable and thus are more easily protected and generate stable revenues (Hearn et al. 2004; Kalantaridis et al. 2017; Saviotti 1998), reducing the potential risks and difficulties for auditors. Thus, in line with Hypothesis 3, higher levels of these two ratios

are expected to moderate the positive commercialization-fees relationship.

4.2.2 | Control Variables

Various control variables are included to capture the main determinants of audit fees which we categorize into the following dimensions: auditee size, auditee complexity, auditee risk, features of the managerial team, and features of auditors. First, auditee size is expected to be positively related to audit fees, as it leads to greater time and efforts for auditors to complete the audit (Chan et al. 1993; Ellwood and Garcia-Lacelle 2015). In line with previous studies, we measure auditee size by the total assets (in a natural logarithm form, *lntlta*) of a university.[6] Additionally, we control for a university-specific variable of size, that is, the logged number of students (*lnstud*).

Second, a higher level of organizational complexity is expected to be positively related to audit fees, as it requires more careful scrutiny into the activities of the auditee and brings higher risks of auditing failure (Simunic 1980). To capture complexity, we draw on Mellett et al. (2007) and Xue and O'Sullivan (2013), and add the following variables: (1) capital expenditure (in a natural logarithm form, *lncap*), (2) the level of reliance on different revenue sources (measured by the proportion of total tuition fees income *tuitionr*, endowment revenues to total revenue *endowr*, and international (i.e., non-UK and non-EU) tuition fee income *int-tuitionr*), and (3) an *olduni* dummy which equals 1 for universities established before the introduction of the Further and Higher Education Act 1992, with new universities established after 1992, that is, mostly former polytechnics, coded 0.

Third, auditors might be more exposed to audit failure and litigation disputes if their auditees are in a higher credit risk category (Giroux and Jones 2007). Even though the financial and business risks of UK universities might be limited due to the unlikelihood of university bankruptcy, auditors may face reputational damage and lose future clients in the long run if their university auditee experiences serious financial distress, incentivizing auditors to charge higher audit fees (Mellett et al. 2007). We follow private- and public-sector studies (e.g., Clatworthy et al. 2002) to measure auditee risk by the gearing ratio (i.e., the liability-to-asset ratio, *leverage*) and the deficit(surplus)-to-asset ratio (*defsur*). Furthermore, in line with Rubin's (1988) municipal-based audit study, the dummy variable *bond* is used to capture any impact of university bond issuing.

Fourth, previous studies demonstrate that key features of the managerial team may impact audit pricing. Given their key role in university managerial and strategic decision-making (Lucey et al. 2022), we add two variables in relation to university vice-chancellors. We include the variable *vcgender*, which is a dummy variable with 1 for male vice-chancellors and 0 for others, and *vcyears*, which measures a vice-chancellor's number of years in office. For *vcgender*, it is possible that female vice-chancellors adopt a more conservative and risk-adverse attitude when performing managerial and operational roles, which may bring less litigative and reputational risks for auditors, leading to lower audit fees (Khlif and Achek 2017; Parker et al. 2015). For *vcyears*, researchers have argued that CEOs with a longer tenure experience less pressure from both external and internal supervision, leading to financial uncertainties and higher audit fees (Cai and Li 2022).

Finally, regarding auditors' features, we control for the dummy variable *big4* (1 for Big 4 auditors and 0 for others) to capture the potential pricing premium, as previous studies show that Big 4 audit firms may extract higher profits due to their perceived higher quality services and stronger market position (Moizer 1997; Teoh and Wong 1993). Furthermore, in line with Mellett et al. (2007), the non-audit charge of the auditors, which in most cases refers to consultancy fees, is also controlled in its natural logarithm form (*lnnonaudit*). A positive relationship between this variable and audit fees is expected, as non-audit-service fees, to some extent, represent auditee size and the necessity for conducting more intensified scrutiny in audit-related services (Clatworthy et al. 2002; Palmrose 1986).

To capture unobservable effects since 2016, when audit fees started to surge faster, we also include a year dummy "yr2016," which gives 1 to years since 2016 and 0 to prior years. Finally, regional dummy variables are also included in the models to control for the potential influence of varying regional economic and political conditions in all nine regions of England (East, East Midlands, London, Northeast, Northwest, Southeast, Southwest, West Midlands, and Yorkshire & Humber), plus Northern Ireland, Scotland, and Wales. Inclusion of the dummy variables for Northern Ireland, Scotland, and Wales also means that we are able to partially control for the different funding models in those countries. For example, government support for knowledge exchange, including IP-related activities, is more generous in England than in the devolved regions (Tracey and Williamson 2023).

4.3 | Estimation Strategies

Using the variables explained above, the following baseline model (1) is established:

$$\begin{aligned}\text{lnauditfees}_{it} = {} & \gamma_0 + \gamma_1 \text{patents}_{it} + \gamma_2 \text{spinoffs}_{it} + \gamma_3 \text{lniprev}_{it} \\ & + \gamma_4 \text{resfund}_{it} + \gamma_5 \text{stemexpr}_{it} + \gamma_6 \text{lntlta}_{it} \\ & + \gamma_7 \text{lnstud}_{it} + \gamma_8 \text{lncapexp}_{it} + \gamma_9 \text{tuitionr}_{it} \\ & + \gamma_{10} \text{int} - \text{tuitionr}_{it} + \gamma_{11} \text{endowr}_{it} + \gamma_{12} \text{olduni}_{it} \\ & + \gamma_{13} \text{leverage}_{it} + \gamma_{14} \text{defsur}_{it} + \gamma_{15} \text{bond}_{it} \\ & + \gamma_{16} \text{vcgender}_{it} + \gamma_{17} \text{vcyear}_{it} + \gamma_{18} \text{big4}_{it} \\ & + \gamma_{19} \text{lnnonaudit}_{it} + \gamma_{20} \text{yr2016}_{t} + \text{region}_{i} \\ & + \mu_i + \delta_t + \varepsilon_{it} \end{aligned} \quad (1)$$

where subscripts i and t separately refer to an observation (university) and a time period (year). Region_i includes a set of the dummies representing the aforementioned UK regions,[7] μ_i and δ_t capture the unobservable university and year-specific effects, respectively. ε is the error term.

To avoid the effects of inter-correlations, our commercialization indicators, that is, *patents*, *spinoffs*, and *lniprev*, are included separately and jointly in our regressions. Subsequently, we investigate the potential moderating effects of research capacity by adding interaction terms, which are established by multiplying *researchr* and *stemexpr* and our commercialization indicators.[8] To avoid serious collinearity, the interaction terms are estimated separately. Our regressions are estimated by the fixed-effect (FE) least squares dummy variable (LSDV) approach. Compared with within-group FE estimation, the LSDV approach ensures that time-invariant variables can be estimated, which means that information on individual-specific effects can be retained (Wooldridge 2010). By doing so, we also address endogeneity issues caused by the unobserved time-invariant factors, which are correlated with the independent variables. Furthermore, we perform various additional tests by employing supplementary measurements, winsorizing the dataset, adopting the system generalized method of moments (system GMMs) estimations (Arellano and Bond 1991), and exploring a specific time period.

5 | Results

5.1 | Summary Statistics and Correlation Analysis

Table 2 shows the summary statistics. For the key variables of concern, it was found that the average level of audit fees is £81,027, with a minimum value of £10,000 and a maximum of £1,596,000. The value of the standard deviation shows a high range of variation for the audit fees of different universities across the years. As presented in Figure 2, the variation of yearly average audit fees was relatively stable before 2015, but after that, it increased quickly and reached £106,000 in 2019. Turning to our commercialization variables, on average over the period 2010/11-2019/20, a British university has 147 patents, 94 active spin-offs, and £1,102,000 in IP revenues per year. All three commercialization variables have a minimum value of 0, showing that there are universities without engagement in knowledge commercialization activities. Our research capacity indicators *researchr* (%) and *stemexpr* (%) have average values of 10.31 and 50.02, respectively, showing that on average, around 10% of UK university revenues come from research grants, whereas 50% of research expenditure goes to STEM disciplines. Still, these two capacity indicators have minimum values equal to 0. This phenomenon, along with the minimum values of 0 for commercialization indicators, suggests that some universities may have limited research capacity, inhibiting their involvement in knowledge-based commercialization.

Table 3 includes the correlation matrix, showing nearly all independent variables have significant correlations with audit fees and that all correlations between the independent variables are smaller than 0.8. In particular, there is a high correlation between variables 1 (audit fees) and 6 (assets), which mirrors the strong positive relationship between audit fees and organization size (as measured by assets here) that is the most consistent finding in the audit fee determinants literature (Hay et al. 2006; Hay 2013). Nevertheless, the levels of multicollinearity in the regression models are well within acceptable limits, despite the correlation between variables 1 and 6. The VIF values reported in the second column of Table 3 are all below 10 (James et al. 2017; Vittinghoff 2005).

5.2 | Main Findings

Fixed-effect regression results are shown in the first four columns of Table 4. When our commercialization indicators are entered separately, all three—patents, active spin-offs, and IP revenue—are positively related to audit fees at the significance levels of 1%, 10%, and 10%, respectively (see Columns 1–3), confirming Hypothesis 1. Aligning with our expectations, this key finding shows that universities that actively commercialize their knowledge face greater audit scrutiny, leading to higher audit fees. This increased scrutiny stems from the complexity involved in valuing university patents and spin-offs, which requires extensive audit effort (Grobler and Niekerk 2011; Datta et al. 2020). The development of university patents and spin-offs also requires large amounts of seed financing and inputs, which have to be audited more carefully (OECD 2000; Rasmussen et al. 2006). In addition, the subsidiaries and spin-off companies established for knowledge commercialization are required to be consolidated into the university's financial statements. The consolidation process involves complex accounting procedures and assessments of inter-entity transactions. Auditors must ensure that these entities adhere to proper governance and financial reporting standards, adding to the overall audit complexity (Wright et al. 2007; Clarysse et al. 2011). Moreover, in many cases, knowledge commercialization requires interdisciplinary collaborations with external entities, such as industry partners and other academic institutions. These collaborations introduce additional complexity in tracking and auditing shared intellectual property rights, financial transactions, and compliance with multiple regulatory frameworks (Rothaermel et al. 2007).

Furthermore, the quality of patents and spin-offs might be a cause for concern. Even if patents and spin-offs have started to generate revenues, these revenues might be unstable and questionable due to highly volatile and uncertain demands (Hearn et al. 2004). Additionally, activities and transactions of knowledge commercialization may suffer more from managerial manipulations such as gaming in valuation and recording (Kim et al. 2019; Visvanathan 2017). In essence, a university's knowledge commercialization activities may elevate auditors' workload and pose risks of auditing failure, which are addressed by higher audit fees. Column 4 in Table 4 reports results with all three commercialization indicators included in the models, in which IP revenues become insignificant due to the high correlation between patents and IP revenues.

Turning to research capacity indicators, our second hypothesis is partially supported. *Researchr* (research revenue to total revenue %) is negatively related to audit fees at the 5% significance level. However, the second indicator, *stemexpr* (STEM-discipline expenditure to total expenditure %), has no significant influence on audit fees. These results may be attributed to the fact that *researchr* is a closer indicator of research capacity, as the allocation of research funding in the UK is directly informed by research quality and outcomes (e.g., informed by the REF evaluation results) (UKRI 2022). Moreover, on the revenue side, a larger ratio of *researchr* illustrates a greater level of revenue diversity,

TABLE 2 | Descriptive statistics.

Variables	*N*	Min	Max	Mean	Median	St. dev
Auditfees (£000)	1232	10	1596	81.027	60	103.419
Lnauditfees	1232	1	3.203	1.813	1.778	0.241
Patents (000)	1224	0	4.409	0.147	0.028	0.389
Spinoffs (000)	1224	0	0.976	0.094	0.047	0.138
Iprev (£000)	1225	0	79,910	1102	41	4786
Lniprev	1225	2.996	4.604	3.037	2.998	0.132
Researchr (%)	1220	0	69.35	10.310	4.939	11.400
Stemexpr (%)	1232	0	100	50.020	52.160	18.970
Tlta (£000)	1224	7196	7,309,571	463,866	282,329	690,895
Lntlta	1224	3.857	6.864	5.443	5.451	0.433
Student (000)	1223	0.345	208.710	18.177	16.750	14.588
Lnstudent	1223	5.844	12.249	9.591	9.726	0.729
Capexp (£000)	1219	0	329,161	31,816	18,514	40,595
Lncapexp	1217	1.477	5.517	4.207	4.268	0.579
Tuitionr (%)	1220	0.079	87.340	49.650	50.530	22.510
Int-tuitionr (%)	1220	0	42.960	11.650	10.910	7.637
Endowr (%)	1220	0.00129	22.820	1.115	0.577	1.684
Olduni	1232	0	1	0.487	0	0.500
Leverage (%)	1223	0	140.300	26.140	24.920	22.790
Defsur	1224	−0.405	0.242	0.019	0.020	0.045
Bond	1232	0	1	0.084	0	0.278
Vcgender	1232	0	1	0.778	1	0.416
Vcyear	1232	0	26	4.884	4	4.143
Bigfour	1232	0	1	0.765	1	0.424
Non-audit fees (£000)	1161	0	1466	56.486	26	97.127
Lnnonaudit	1161	0	3.166	1.326	1.415	0.677
yr2016	1232	0	0	0.407	0	0.491

which is linked to lower audit risks and, consequently, lower audit fees. Instead, *stemexpr*, on the expenditure side, reflects a university's ambition to improve research but may not perfectly represent the current capacity to achieve such improvement. Further, compared with social science and humanities disciplines, providing and maintaining STEM disciplines is expensive, which might pose financial risks for a university's operations. Thus, a higher *stemexpr*, as indicated by the results, neither alleviates nor increases auditors' concerns.

Regarding the control variables, first, in line with previous studies (e.g., Chan et al. 1993; Clatworthy et al. 2002), (ln) total asset is positively related to audit fees at the 5% significance level, whereas the second university size indicator *lnstudent* (logged number of students) is statistically insignificant. For auditee complexity, (ln) capital expenditure is negatively related at 10%. This is possibly because a university's capital expenditures on property, plant, and equipment (PP&E), such as teaching, research, and accommodation infrastructures, could improve earnings performance and bring excess returns for the university in the long run, thus reducing financial risks and uncertainty as perceived by auditors (Jiang et al. 2006; Kerstein and Kim 1995). Then, the percentage of tuition fees to total revenue is negatively related at 5% and 1% significance levels. Compared with other sources of funding, including financially more complex research-related funding, tuition fees account for the largest and most stable part of university revenue. Thus, a higher ratio of *tuition* may bring less complexity for auditors, leading to lower audit fees. This result is consistent with previous qualitative and quantitative evidence on the relationship between tuition income and audit pricing in universities (Xue and O'Sullivan 2013). The other three complexity indicators, that is, the reliance on international tuition fees and endowments as well as the *olduni* dummy, have no significant influence on audit fees.

One of our three auditee risk indicators, *bond*, is positively related to audit fees (at 5% and 10%), whereas the other two *leverage* and *defsur* are statistically insignificant. This is possibly due to the expectation amongst many stakeholders that UK universities with financial risks will be rescued by the government in case

TABLE 3 | Correlation matrix and VIF values.

	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Lnauditfees		1																				
2. Patents	1.88	0.6195*	1																			
3. Spinoffs	1.23	0.2099*	0.1371*	1																		
4. Lniprev	1.57	0.4919*	0.7314*	0.1139*	1																	
5. Lnnonaudit	1.25	0.3352*	0.2260*	0.1515*	0.1747*	1																
6. Lntlta	6.68	0.7101*	0.5378*	0.2578*	0.4040*	0.3439*	1															
7. Lnstudent	3.38	0.4379*	0.2150*	0.2723*	0.1651*	0.2275*	0.6889*	1														
8. Lncapexp	2.83	0.5009*	0.4153*	0.1996*	0.2561*	0.3222*	0.7779*	0.5495*	1													
9. Tuitionr	1.62	−0.1428*	−0.2788*	0.1172*	−0.1858*	−0.0361	−0.0497	0.1287*	−0.0280	1												
10. Endowr	1.41	0.3738*	0.3693*	−0.0207	0.3308*	0.1047*	0.3300*	0.0168	0.2391*	−0.1807*	1											
11. Int-tuitionr	1.45	0.2054*	0.0692*	0.0184	−0.0087	0.1097*	0.2960*	0.1593*	0.3380*	0.1028*	0.2373*	1										
12. Leverage	1.78	0.0265	−0.00820	0.0219	0.0236	−0.1044*	−0.0144	−0.1565*	−0.0428	0.0727*	0.1013*	0.00330	1									
13. Defsur	1.14	−0.0396	0.0501	−0.0481	0.0391	−0.0047	−0.0750*	0.0003	−0.0023	−0.0758*	0.1073*	−0.0250	−0.1198*	1								
14. Bond	1.20	0.3997*	0.2903*	0.0574*	0.2472*	0.1241*	0.3594*	0.1657*	0.2884*	−0.0288	0.2228*	0.1471*	0.1070*	0.00510	1							
15. Bigfour	1.27	0.2016*	0.1575*	0.0932*	0.1100*	0.2756*	0.2792*	0.2340*	0.2135*	−0.1857*	0.1093*	0.1061*	−0.1410*	−0.0302	0.0923*	1						
16. Researchr	4.51	0.4167*	0.5139*	−0.0380	0.2887*	0.2577*	0.4576*	0.0151	0.3731*	−0.4971*	0.3106*	0.1720*	0.0698*	0.00850	0.2064*	0.1732*	1					
17. Stemexpr	2.12	0.3826*	0.3025*	0.0733*	0.1636*	0.2702*	0.4542*	0.3160*	0.3195*	−0.2897*	0.1061*	0.0629*	0.0588*	−0.0690*	0.1565*	0.2028*	0.6143*	1				
18. Olduni	2.76	0.3676*	0.3462*	−0.1377*	0.2180*	0.2205*	0.4653*	0.1325*	0.4060*	−0.3265*	0.3705*	0.4410*	0.0463	−0.0318	0.1714*	0.2136*	0.6893*	0.3819*	1			
19. Vcgender	1.12	0.0538	−0.0371	0.0403	−0.0400	0.0967*	0.0445	0.1010*	0.1338*	−0.0412	−0.0114	0.0160	−0.0252	0.1036*	0.0079	−0.0059	0.0585*	0.0452	0.0798*	1		
20. Vcyear	1.05	−0.0958*	−0.1146*	−0.0403	−0.0819*	−0.0310	−0.0421	−0.0294	−0.0260	0.0312	−0.0910*	−0.0602*	−0.0049	0.0221	−0.0570*	0.0409	−0.0623*	−0.0337	−0.0942*	0.0934*	1	
21. yr2016	2.07	0.1727*	0.0406	0.1221*	0.0918*	−0.0443	0.1823*	−0.0005	0.0373	0.2251*	0.0931*	0.0402	0.5852*	−0.2626*	0.1528*	−0.0409	−0.0384	0.0367	−0.00660	−0.1175*	0.0543	1

Note: "*" is for coefficients significant at 5%.

TABLE 4 | Impact of knowledge commercialization and other determinants of university audit fees, panel data 2010–2019. Dependent variable: natural log of audit fees. FE-LSDV regressions.

	(1)	(2)	(3)	(4)
		FE		
Patents	0.113***			0.092**
	(0.04)			(0.04)
Spinoffs		0.122*		0.111
		(0.07)		(0.07)
Lniprev			0.121*	0.067
			(0.06)	(0.06)
Researchr	−0.004**	−0.005**	−0.004**	−0.003**
	(0.00)	(0.00)	(0.00)	(0.00)
Stemexpr	0.000	−0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Lntlta	0.097**	0.118**	0.097**	0.102**
	(0.05)	(0.05)	(0.05)	(0.05)
Lnstudent	0.048	0.041	0.048	0.043
	(0.03)	(0.03)	(0.03)	(0.03)
Lncapexp	−0.017*	−0.017*	−0.016*	−0.016*
	(0.01)	(0.01)	(0.01)	(0.01)
Tuitionr	−0.001**	−0.002***	−0.001**	−0.001**
	(0.00)	(0.00)	(0.00)	(0.00)
Int-tuitionr	−0.001	−0.001	−0.001	−0.001
	(0.00)	(0.00)	(0.00)	(0.00)
Endowr	0.003	0.004	0.003	0.003
	(0.00)	(0.00)	(0.00)	(0.00)
Olduni	−0.082	−0.000	−0.072	−0.043
	(0.09)	(0.11)	(0.09)	(0.10)
Leverage	−0.000	−0.000	−0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Defsur	−0.032	−0.018	−0.035	−0.027
	(0.08)	(0.07)	(0.08)	(0.07)
Bond	0.047**	0.055**	0.047**	0.043*
	(0.02)	(0.02)	(0.02)	(0.02)
Vcgender	0.033***	0.033***	0.036***	0.034***
	(0.01)	(0.01)	(0.01)	(0.01)
Vcyear	−0.000	0.000	−0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Bigfour	0.002	−0.005	0.000	−0.001
	(0.02)	(0.02)	(0.02)	(0.02)
Lognonaudit	0.013*	0.015**	0.014**	0.013*
	(0.01)	(0.01)	(0.01)	(0.01)
yr2016	0.158***	0.149***	0.158***	0.145***
	(0.02)	(0.02)	(0.02)	(0.02)
_cons	0.756*	0.675*	0.400	0.539
	(0.40)	(0.39)	(0.43)	(0.42)
Region	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	1143	1143	1143	1143
Adj. R^2	0.88	0.87	0.88	0.88
F	115.96***	130.73***	123.03***	119.23***

Note: This table reports findings from FE-LSDV regressions. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. Hausman test statistics prefer fixed-effect regressions over random-effect and pooled-OLS regressions in all specifications.

Abbreviations: FE, fixed-effect; LSDV, least squares dummy variable.

of serious financial distress, reducing short-term financial risks associated with audit efforts (Coughlan 2019). However, bond issuance brings long-term uncertainties and a more complex financing structure resulting in auditors needing to devote greater efforts and more compensation for auditing failure and reputation loss (Hay et al. 2006). The dummy variable *vcgender* shows a positive significant coefficient at 1%, which is in line with previous studies that male leaders may adopt more radical and risk-favoring attitudes in managerial practices, leading to higher audit fees (Khlif and Achek 2017). We find no evidence supporting the influence of a vice-chancellor's (*vcyears*) tenure in office on audit fees. Regarding auditors' features, we further find no evidence for a Big 4 auditor premium. However, in line with Mellett et al. (2007), we do identify a significantly positive relationship between auditors' non-audit and audit charges at 5% and 10% significance levels. Finally, the *yr2016* dummy is positive and significant at 1% in all specifications.

5.3 | Moderation Effects of Research Capacity

Table 5 reports the moderation effects of two research capacity indicators, *researchr* and *stemexpr*, by adding interaction terms *commercialization*capacity* to the models. The results show that all moderators have negative coefficients, with all of them statistically significant at the 1% level, apart from one specification being significant at 5%. This finding aligns with our expectation that universities with stronger research capacity are better positioned to develop patents and spin-offs and generate other intellectual property that can be successfully commercialized and generate stable returns. In this case, auditors might be less concerned about university commercialization activities, resulting in lower audit fees (Hearn et al. 2004; Rasmussen et al. 2006). To examine these moderation effects in greater depth it is instructive to plot them.

Figure 5 shows the decreasing effects of commercialization with the growth of research capacity, in which the upper and lower dash lines represent the 95% confidence interval. Statistically significant moderation effects can be confirmed when the upper and lower bounds are above and/or below the zero line (Brambor et al. 2006). The figure shows that research capacity consistently

TABLE 5 | Moderation effects of research capacity on the commercialization-audit fees relationship, panel data 2010–2019. Dependent variable: natural log of audit fees. FE-LSDV regressions.

	(1)	(2)	(3)	(4)	(5)	(6)
				FE		
Patents	0.210***	0.181***				
	(0.03)	(0.05)				
Spinoffs			0.024	0.067		
			(0.07)	(0.05)		
Lniprev					0.365***	0.409***
					(0.12)	(0.10)
**Pat*res	−0.009***					
	(0.00)					
Pat*stem		−0.006**				
		(0.00)				
Spinoffs*res			−0.021***			
			(0.01)			
Spinoffs*stem				−0.008***		
				(0.00)		
Lniprev*res					−0.017***	
					(0.01)	
Lniprev*stem						−0.018***
						(0.00)
Researchr	−0.001	−0.003**	−0.005***	−0.005**	−0.003**	−0.003**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Stemexpr	−0.000	−0.000	−0.000	−0.000	0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lntlta	0.093*	0.095*	0.135***	0.134***	0.091*	0.091*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Lnstudent	0.055	0.044	0.047	0.028	0.054	0.056
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
Lncapexp	−0.014	−0.017*	−0.016*	−0.017*	−0.015	−0.013
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tuitionr	−0.001**	−0.001**	−0.002***	−0.002***	−0.001**	−0.001**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Int-tuitionr	−0.001	−0.001	−0.000	−0.000	−0.001	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Endowr	0.003	0.003	0.004*	0.004	0.004	0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Olduni	−0.133	−0.104	0.073	0.106	−0.090	−0.096
	(0.09)	(0.09)	(0.11)	(0.12)	(0.09)	(0.09)
Leverage	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Defsur	−0.016	−0.033	−0.013	0.003	−0.027	−0.029
	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)
Bond	0.030	0.048**	0.059**	0.057**	0.038*	0.032
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)

(Continues)

TABLE 5 | (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)
Vcgender	0.044***	0.035***	0.037***	0.034***	0.037***	0.033***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Vcyear	−0.001	−0.000	−0.000	−0.001	−0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Bigfour	0.005	0.002	−0.006	−0.010	−0.001	0.002
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Lognonaudit	0.012*	0.013*	0.013*	0.014**	0.015**	0.014**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
yr2016	0.165***	0.156***	0.153***	0.148***	0.159***	0.156***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
_cons	0.683*	0.840**	0.459	0.639*	−0.367	−0.481
	(0.39)	(0.41)	(0.38)	(0.36)	(0.53)	(0.50)
Region	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	1143	1143	1143	1143	1143	1143
Adj. R^2	0.88	0.88	0.88	0.88	0.88	0.88
F	124.79***	119.22***	121.67***	133.60***	122.13***	133.64***

Note: This table reports findings from FE-LSDV regressions. *T*-statistics based on robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Hausman test statistics prefer fixed-effect regressions over random-effect and pooled-OLS regressions in all specifications.

Abbreviations: FE, fixed-effect; LSDV, least squares dummy variable.

moderates the commercialization–fees relationship, especially in specifications where commercialization is measured by patents and IP revenues. Substantively speaking, the positive effect of both commercialization indicators on audit fees is eradicated at *researchr* of about 18% (just under one standard deviation more than the mean) and at *stemexpr* of about 20% (around 1.5 standard deviations less than the mean). Most universities therefore appear to be able to reduce risks related to commercialization due to their investments in STEM fields, whereas some appear to be reducing these risks further by securing large amounts of research grants. These findings provide further support for Hypothesis 3. However, the graphs additionally suggest that in universities with the highest levels of research capacity, the positive commercialization–audit fee relationship is not only eradicated but that the combined effect of high capacity and commercialization results in lower audit fees than for universities at the other end of the capacity-commercialization spectrum.

5.4 | Robustness Checks

Various additional tests are conducted to ensure robustness. First, as several observations of (ln) non-audit fees were missing (1161 observations, compared to 1232 for audit fees), we estimated the models without controlling this variable. Subsequently, to mitigate the effect of outliers, we winsorize the dataset of our three commercialization indicators at the 1st and 99th percentiles and 5th and 95th percentiles, respectively, and consistent results are identified. Further, we use the number of subsidiaries controlled by a university as an alternative knowledge commercialization indicator (see Supplementary analysis 1.1). Although this is a less precise indicator compared to spin-offs, as it includes non-knowledge-based commercial activities such as catering and accommodation, we find a similarly significant positive relationship between subsidiaries and audit fees, as well as the moderation effects of *researchr* and *stemexpr*. Then, to address endogeneity from omitted variable bias and reverse causality (Abdallah et al. 2015), we conducted system GMM estimations,[9] which revealed similar results to our main findings (see Supplementary analysis 1.2). We also conducted separate estimations for the period 2016–2019, as audit fees started to rise faster since 2016, and consistent results for the main independent variables are still identified (see Supplementary analysis Information 1.3).

6 | Conclusions

This study offers insights into UK universities' commercialization activities and audit fees, addressing both an important academic gap and a topic of increasing relevance for stakeholders in higher education, government, and audit. The results suggest that external auditors are undertaking more extensive efforts and scrutiny to uphold the financial accountability of universities that engage more with knowledge commercialization. Furthermore, auditors appear to perceive universities with greater research capacity to be better equipped to succeed in knowledge commercialization activities, thereby alleviating auditor concerns about the financial risks relating to commercialization and moderating the positive commercialization–fees relationship.

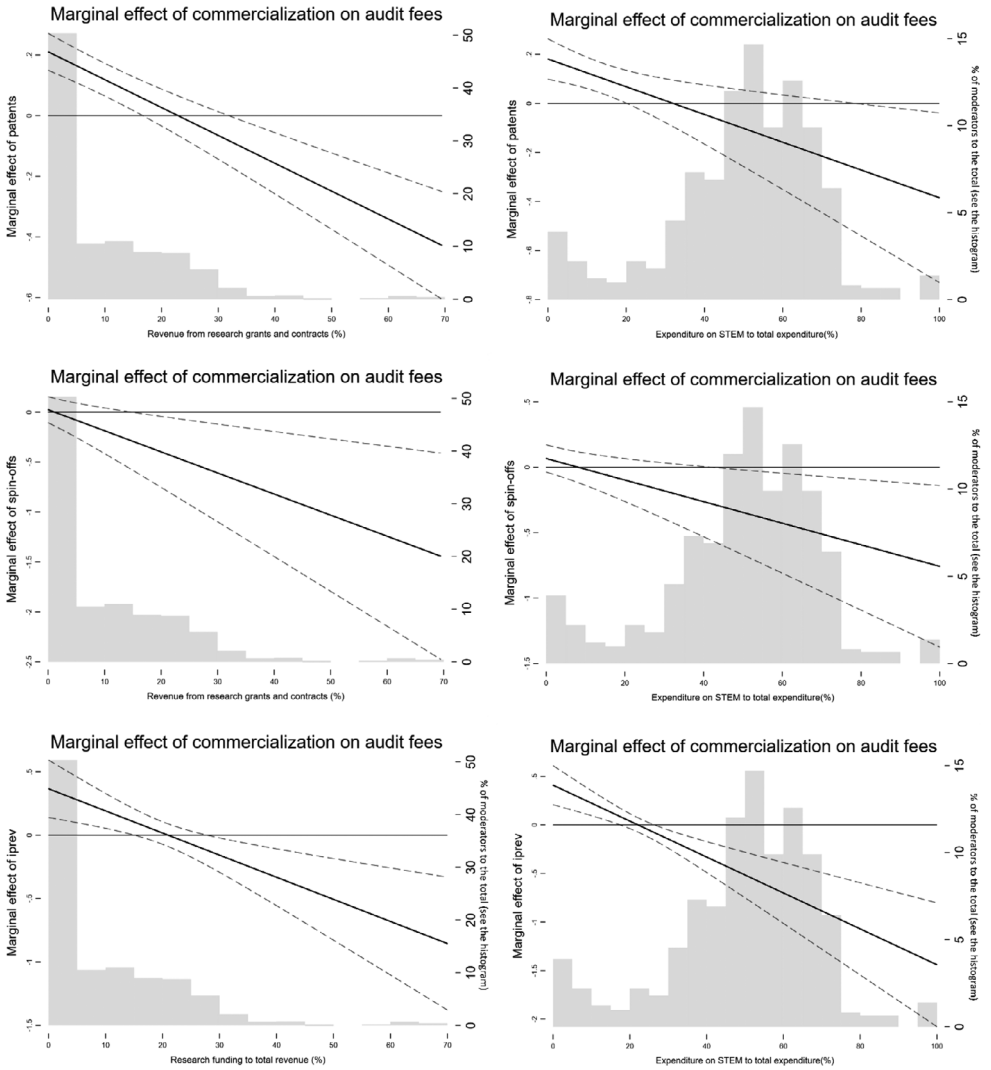

FIGURE 5 | Moderation effects of research capacity.

These findings have important implications for policymakers as they illustrate the ways in which financial accountability for universities is evolving. First, regulatory bodies should pay greater attention to knowledge commercialization within universities, especially in low-capacity institutions. Given their responsibility for upholding the financial sustainability of universities, entities, such as the OfS, could scrutinize commercial activities as part of their duty to gather intelligence on universities' financial risk and be armed with powers to intervene in those activities when they are deemed to be excessively risky. Second, collaboration and knowledge sharing of best practices in undertaking commercial activities should be encouraged among universities, for example, in relation to funding models for TTOs that contribute to both innovation as well as financial sustainability. Collaboration could also include more formalized partnerships to help build scale and critical mass when universities engage in research commercialization. This could include the creation of shared TTOs (cf., Tracey and Williamson 2023), which would be particularly relevant to reduce risks for smaller and more teaching-focused universities that currently appear less equipped to engage with research commercialization. Third, in addition to more central oversight of the risks associated with commercialization in higher education, universities, regulatory agencies, professional bodies, and audit firms should collectively reflect on the nature of the audit market for universities. Questions have been raised in the past about the extent to which audit firms can be trusted to accurately represent risk when upholding the financial accountability of public services that are managed at arms-length (House of Commons 2018). Stakeholders should therefore consider whether the auditing requirements for universities may require revision to accommodate increasing commercialization across the higher education sector, including in light of other changes affecting the financial profile of British universities, such as growing volatility in (international) tuition fee income and increasing indebtedness (Bell et al. 2022).

The findings of this article provide several directions for future research. First, although our study is UK-focused, commercialization is being undertaken by universities in many countries. However, the degree of commercialization in higher education, as well as the audit environment in which universities operate, differs across countries (Brusca et al. 2016; Mustar et al. 2008). Studies on jurisdictions beyond the UK, and more explicit country comparative studies, are likely to generate valuable insights as

to how variations in commercialization models and audit environments affect university audit pricing (Hay and Cordery 2018). Second, although the results of our study indicate differences between universities in how auditors perceive risks related to research commercialization, we have limited knowledge on how this subsequently impacts financial assurance and accountability processes, including whether these differ depending on the type of commercialization activity universities engage with. Further, greater research capacity is likely to be reflected in greater managerial and operational capacity in managing knowledge commercialization. However, at present, we have limited knowledge of how universities manage knowledge commercialization and the risk-return trade-off in relation to these activities. More studies, of both quantitative and qualitative nature, promise to provide valuable insights into how universities may engage most effectively with knowledge commercialization.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

[1] For England, this is confirmed by a recent review on how English universities spent government funding received from the Higher Education Innovation Fund (HEIF). Although English universities spent on average 16% of HEIF on technology transfer, this figure was 23% amongst the most research-intensive universities (Ulrichsen 2020).

[2] We exclude universities and colleges specializing in applied domains, such as art and design, or agriculture, as due to their specialized focus and often small scale, these institutions are incomparable in many ways to the main public universities.

[3] These bodies are the Scottish Funding Council (SFC) in Scotland and the Higher Education Funding Council for Wales (HEFCW) in Wales, whereas the higher education sector in Northern Ireland is overseen by the Department for the Economy of the Northern Ireland Executive.

[4] Cumulative patent portfolio includes the number of individual active and live patents. Active patents are those currently registered under license to an external party. Live patents are those registered but yet to be licensed.

[5] We have no access to data on STEM research grants, thus choosing the STEM expenditure ratios as an alternative.

[6] Previous research studies, including private-sector focused studies (e.g., Xue and O'sullivan 2013), also adopt the logged total income to measure auditee size. We explored the effects of this variable in separate regressions as it is highly correlated with the logged total assets. Consistent results are identified and can be provided on request.

[7] For simplicity, estimates of regional dummies are not reported in the main text but can be found in Supplementary analysis 1.5.

[8] For simplicity, interaction terms are *pat*res*, *pat*stem*, *ip*res*, *ip*stem*, *spin*res*, and *spin*stem*.

[9] When employing system GMM estimations, we adopt three-year lagged dependent variables (i.e., *logauditfees*), which ensures any decreasing effects of the audit fees in prior years are captured while keeping most of the sample observations (Ullah et al. 2018). Finally, as a key procedure of running system GMM, we consider all time-varying variables as endogenous (lagged values will be the instruments) as they may, more or less, be related to the unobservable factors that are not controlled in the model (Veronesi et al. 2019).

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.