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Anticipatory innovation of professional services: The case of auditing and artificial intelligence

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ABSTRACT

With the rise of artificial intelligence (AI), professional services firms (PSFs) need to innovate their services to adapt to AI. However, traditional ad hoc innovations driven by individual professionals have limitations in incorporating new technology outside their expertise. Although service R&D—an organizational function for centralized coordination of service innovations in strategically targeted areas—is potentially effective, studies on service R&D have still been scarce. This case study aims to fill the gap by examining how PSFs can establish and utilize service R&D to innovate services, overcoming the challenges of AI adoption. An in-depth qualitative study was conducted on the process by which the Big Four audit firms incorporated AI into their external audit service in Japan in the 2010s. The analysis shows the detailed process of how newly created service R&D organizations advanced AI adoption in the case firms. This study contributes to the literature on innovations in services and PSFs by (1) demonstrating the neglected but critical role of service R&D as an innovation enabler beyond the existing expertise of service firms, (2) constructing a three-phase model of the evolution of the service R&D function, and (3) suggesting the significance of innovation process design for the legitimation of innovations. This study also expands our knowledge of AI adoption, presenting a process tailored to address the challenges inherent in AI adoption for PSFs.

1. Introduction

Professional service firms (PSFs) are knowledge-intensive business service firms with high knowledge intensity, low capital intensity, and a professionalized workforce (von Nordenflycht, 2010). Previous research has suggested that they are important innovators in the universe of service firms (Anand et al., 2007; Barrett and Hinings, 2015; Criscuolo et al., 2007). The recent rise of digital technology—artificial intelligence (AI)[1] in particular—has begun to impact various jobs at organizations (Hunt et al., 2022). The technological change has also urged service firms and PSFs to innovate their services further because digitalization brings forth both opportunities for new service provision and threats of technological substitution by new businesses, such as Lawtech and Fintech firms (Hinings et al., 2018; Huang and Rust, 2018). Indeed, scholars have reported emerging innovations driven by AI in various professional services, such as auditing (Goto, 2022; Pemer, 2021), legal services (Armour and Sako, 2020; Kronblad, 2020), and management consulting (Tavoletti et al., 2022).

However, PSFs need to overcome their unique challenges in innovating services. In this regard, past studies have highlighted that the difficulty of innovation in PSFs lies in balancing professional autonomy and central control. On the one hand, innovation in services centers around ad hoc innovations that emerge from individuals' efforts in ongoing services (Gadrey and Gallouj, 1998; Sorensen et al., 2013). Improvisations by frontline professionals are necessary because it is difficult to centrally predetermine what new knowledge will be required to customize services under varied contexts (Barrett and Hinings, 2015). Consequently, previous studies on innovation in PSFs have intensively reported the bottom-up incremental approach; individual professionals generate potential seeds of innovation by leveraging their networks and client interactions (Criscuolo et al., 2007). Such innovation seeds need to establish legitimacy before being diffused within a PSF because frontline professionals usually have a controlling stake in specific services that should be provided to each customer (Brivot, 2011; Gardner

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[1] In this study, "artificial intelligence (AI)" is defined as computer software that performs "cognitive functions that are usually associated with human minds, such as learning, interacting, and problem solving" (Raisch and Krakowski, 2021, p. 192). Its major applications include those substituting for human cognition, such as image recognition, voice recognition, and natural language processing (Yang, 2022), as well as performing data analyses, which is generally supported by machine learning for prediction and pattern recognition.

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et al., 2008).

On the other hand, scholars have also recognized that, along with individual professionals' efforts, service firms can benefit significantly from utilizing a centralized R&D function, like their manufacturing counterparts, to develop new knowledge in strategically targeted areas (Doloreux et al., 2016). Such an organizational function in service firms has been recognized as the "service R&D" (Miles, 2007) that is created through top-down innovation initiatives and coordinates innovation practices and activities (Dougherty, 2004). Service R&D focuses on service firms' resources and efforts to materialize innovations in targeted areas to acquire and coordinate new knowledge, to enable expertise-field or anticipatory innovation (Gallouj, 2002; Gadrey and Gallouj, 1998).[2] In innovating professional services using AI, professionals must incorporate what resides outside their expertise and current services into their professional services. Consequently, service R&D has the potential as a critical enabler of technological transformation in PSFs (Dougherty, 2004). However, few studies have addressed how PSFs can leverage service R&D in innovations to incorporate a new knowledge area of integrating AI.

In addition, although recent studies have identified factors that promote firms' AI adoption (e.g., Kinkel et al., 2022) and resulting outcomes such as firm performance (e.g., Lee et al., 2022), few studies have addressed how firms adopting AI can successfully manage the process of innovation with AI, which is an important issue for theory and practice. For the context of AI adoption by PSFs in particular, emerging studies have implied that the nature of AI technology provides specific challenges: high uncertainty due to external factors surrounding PSFs, such as regulations and societal expectations (Goto, 2022), obscure limits of AI capacity in its replacement of human expert tasks (Pakarinen and Huising, 2023), and cultural barriers for professionals to accepting role changes caused by new technology (Goto, 2021).

Taking the context of AI adoption as a specific example, this study explores how PSFs can establish and utilize service R&D to innovate their services. Specifically, this qualitative study investigates the case of the Big Four audit firms that incorporated AI into their external audit services in Japan in the 2010s. This context enables insight into newly established service R&D that has played a central role in the AI adoption process of major firms, and their innovation processes were analyzed drawing on 68 interviews (held with them during 2017–2020) and on archival data, such as the firms' internal documents and external publications (including websites and videos).

This study makes three contributions to the theory of innovation in services and PSFs. First, it demonstrates the critical role of service R&D in driving innovations beyond the existing expertise of service firms. The study shows how developing a dedicated innovation function helps firms achieve expertise-field/anticipatory innovation aimed at incorporating new technology. Second, it constructs a model that exhibits how innovations enabled by service R&D unfold. The findings suggest that innovations enabled by service R&D progress in three phases, in which the service R&D organization expands, manages a shifting portfolio of innovation activities, and adjusts its operating principles according to the progress of digital innovations. Third, this study adds to our knowledge of how innovations in service firms can be legitimized. Expanding the already reported legitimation strategies at the rhetoric and negotiation tactics level, this study shows that the design of innovation processes, such as involving frontline professionals and linking firm-wide change with societal change, can contribute to innovation legitimation. In addition, this study also contributes to expanding our knowledge of AI adoption, in the context of PSFs in particular, by demonstrating a process tailored to address the challenges inherent in AI adoption for PSFs. With these findings and implications, this research demonstrates the significance and peculiarity of the centralized R&D function in services.

This paper is structured as follows. The next section reviews the literature, focusing on service innovation and its challenges in PSFs, followed by a review of service R&D as the theoretical lens for this study. The section concludes with a review of the recent literature on AI adoption, focusing on the PSF context. Next, the empirical case study context and the research methodology are explained. The following section presents the findings, while the concluding section discusses the implications and limitations of this study.

2. Theoretical background

2.1. Innovation in PSFs

With the rise of the service economy, there has been an increasing interest in how services can be innovated and how those innovations differ from those in the manufacturing sector (Gallouj and Weinstein, 1997; Hipp and Grupp, 2005). Professional services have been an important contributor to service innovation among various service sectors because PSFs need to continue responding to increasingly sophisticated client needs (Anand et al., 2007). Through close interactions and knowledge coproduction with clients and business partners, PSFs can continue acquiring service-centric knowledge and improving service value for clients (Dougherty, 2004; Gann and Salter, 1998, 2000). Past studies have highlighted that innovations in professional and other service firms center around frontline staff's improvisations in daily practice, enhanced by knowledge sharing and client interactions (Criscuolo et al., 2007; Melton and Hartline, 2013). The underlying assumption is that service innovation requires learning through client feedback and exchanges with other professionals and service vendors for ideation and codification (Gann and Salter, 2000). The need for such interactions comes from the inherent ambiguity of knowledge in services (Anand et al., 2007; Dougherty, 2004) and the difficulty of predetermining what specific service can add value for clients in customized professional services (Taminiau et al., 2009). For these reasons, knowledge created and updated on the frontline plays a vital role in service innovation (Fosstenlokken et al., 2003). Indeed, most PSF innovation studies have reported bottom-up innovations developed among frontline professionals (Barrett and Hinings, 2015; e.g., Fosstenlokken et al., 2003; Rogan and Mors, 2017). These studies have suggested the significance of knowledge sharing (Taminiau et al., 2009; Valtakoski and Jarvi, 2016) and knowledge management (Brivot, 2011; Fu, 2015), because networking in different knowledge domains within and across organizations stimulates knowledge exploration and exploitation (Hidalgo and D'Alvano, 2014; Mors et al., 2018). Thus, to generate and exploit new forms of knowledge through networks, PSFs need to design organizational structures carefully (Anand et al., 2007) and promote informal boundary-spanning ties (Mors et al., 2018).

As innovation involves multiple actors and interactions among multiple practices, its process likely involves contestations due to two factors particular to PSFs. First, PSFs have structural difficulty in coordinating resources for innovation across teams (Barrett and Hinings, 2015). PSFs rely on professionals' autonomy in service delivery; it is the individual professionals who can materialize the best solutions for each client based on their expertise and client understanding. The knowledge of individuals is a critical resource in this sense, and thus they have a strong bargaining position (Robertson et al., 2003). Furthermore, individual professionals often lack incentives to align with innovation goals (Barrett and Hinings, 2015; Taminiau et al., 2009; Valtakoski and Jarvi, 2016). They are usually rewarded by individual billable hours instead of contributions to collective innovations. Peer competition and intense performance pressure can further demotivate professionals to collaborate (Gardner, 2012). Consequently, past studies often stressed that developing innovation capacity in PSFs requires the leading partners' strong leadership for process innovation (Villani et al., 2021).

Second, the legitimacy of innovation vis-à-vis past practices is often

[2] The definitions of these various types of innovation will be explained in the subsequent literature review section.

problematized in PSFs (Gardner et al., 2008). Due to the priority of professional autonomy, individual professionals can easily refuse new practices to protect their established practices and avoid the burden of practice change. As a result, even when a seed of innovation is developed, professionals do not simply follow the new practice but often resist its adoption (Borjeson and Lowstedt, 2017). Furthermore, professional logic affects the acceptability of innovations within PSFs (Hinings et al., 1991). That is, innovations can be resisted if professionals perceive them as violating the professional values of what is appropriate for the profession (Sako, 2015). Therefore, obtaining and establishing legitimacy is also critically important in service innovation in PSFs (Barrett and Hinings, 2015).

2.2. Service R&D

While the significance of the bottom-up approach has been stressed for PSFs, past studies have suggested other approaches for service innovations with varied degrees of central coordination. In particular, Gadrey and Gallouj (1998) and Gallouj (2002) clarified three types of service innovation: ad hoc, anticipatory ("expertise-field" in Gadrey and Gallouj, 1998), and formalization innovations. Ad hoc innovation is a non-programmed form of innovation arising in service exchanges, "creating and utilizing synergies out of available knowledge and experience accumulated in the course of past practice" (Gadrey and Gallouj, 1998, p. 8). It is most frequently observed but often not replicable. Anticipatory or expertise-field innovation is planned strategic activities for developing new spheres of knowledge by "detecting new needs and responding to them through a procedure of accumulating knowledge and expertise" (Gadrey and Gallouj, 1998, p. 10). Although frontline needs and service provision are still important in this type of innovation, anticipatory innovation highlights the value of systematic top-down interventions. The third category, formalization innovation, addresses the systematic replication of other types of innovations. It can sometimes proceed outside client interactions as a purely internal innovation diffusion initiative.

Advancing this line of inquiry, *service R&D*, the application of research and development (R&D) organizational functions prevailing in manufacturing firms to service firms, has been pointed out as a neglected but important perspective (Miles, 2007). Generally, R&D is defined as "creative and systematic work undertaken in order to increase the stock of knowledge—including knowledge of humankind, culture, and society—and to devise new applications of available knowledge" (OECD, 2015, p. 44). Service firms, particularly knowledge-intensive business services, do create, manage, and leverage their internal research capability and R&D organization (Bourke et al., 2020; Doloreux et al., 2016; Hipp and Grupp, 2005; Miles, 2007). However, regardless of its potential diffusion and essential role, service R&D has not been sufficiently studied due to our bias in recognizing R&D only in a form similar to traditional manufacturing R&D (Doloreux et al., 2016; Miles, 2007). Thus, there has been a call for further study of how it unfolds (Dougherty, 2004).

Although limited in number, some studies have explored service R&D in empirical settings. For example, in studying innovations in 10 IT and other service firms, Dougherty (2004) highlighted the value of service R&D that differs from manufacturing R&D. She noted that "organizing corporate R&D [for services] to focus on the practice, not only on basic science or technologies, enables people to reflect in action on practices" (p. 53). In her study, newly created formal R&D reportedly facilitated strategic trend watching, knowledge exchanges across different expertise areas, and accumulation and diffusion of ideas for innovation, although most new knowledge was developed on an ad hoc basis within ongoing projects that were billed to clients. Similarly, Hidalgo et al. (2021) studied innovation management in nine Spanish consulting firms and identified various innovation processes. One archetype is "management-driven innovation," in which an executive (chief innovation officer) was appointed to manage an innovation management office that articulated the initiatives and resources needed for innovation. The service R&D unit facilitated knowledge exchanges among professionals and formalized frontline experiences and capabilities. Even in highly professionalized contexts, such as legal services, Bourke et al. (2020) revealed the significance of a structured and organized approach to innovation. Based on a survey of approximately 1500 law firms, they found that establishing an internal research function drove codification activities and positively contributed to service innovation.

In summary, some studies have suggested that managerial interventions can coordinate, reproduce, and exploit innovations in services (Rubalcaba et al., 2012). Developing a dedicated organizational function for innovation, such as service R&D, can be an effective approach to innovating services in PSFs, firms with peculiar challenges for innovation, particularly when they need to incorporate new knowledge beyond individual frontline professionals' reach. However, our knowledge is scant on how PSFs can utilize service R&D.

2.3. AI adoption in professional services

As Eggers and Francis Park (2018) pointed out, how incumbent actors adapt to and adopt technological change has been an important issue in organizational and innovation research. Among the various technologies, AI has increasingly been adopted by organizations to innovate. Thus, it has become an important object of scholarly attention, particularly in terms of the antecedents and outcomes of its adoption (Mariani et al., 2023). Studies on the antecedents of AI adoption by organizations have identified various factors that promote adoption: technological factors such as trust in AI (Bedue and Fritzsche, 2022), organizational factors such as digital skills, company size, and R&D intensity (Kinkel et al., 2022), and environmental factors such as institutional pressure (Bag et al., 2021). Another stream of research, on AI adoption outcomes, has revealed potential significant influences of AI in various aspects, such as job satisfaction (Nguyen and Malik, 2022) and firm performance (Lee et al., 2022).

Although these studies have enriched our knowledge of AI adoption at the aggregated level, few studies have addressed how firms adopting AI can successfully manage the process to achieve positive outcomes. Indeed, many organizations are still struggling to incorporate AI, and thus more detailed exploratory studies of firm-level factors are called for (Kinkel et al., 2022). As Mariani et al. (2023) pointed out, "qualitative methods should be embraced more widely to better capture processes of AI adoption and use over time, as well as their outcomes, in a longitudinal fashion" (p. 20).

For professional services, which is the context of this study, the emerging literature on AI adoption has suggested peculiar challenges in three aspects. First, professionals need to manage the significant uncertainty arising from their embeddedness in their professional fields, with fluctuating regulations and shifting societal expectations (Goto, 2022). Even if AI adoption is technically possible, it may be subject to regulatory restrictions or may not be accepted due to social norms. Combined with the unpredictability of AI's technological evolution, planning systematic AI adoption by professional services is challenging.

Second, it is difficult to predict whether AI can effectively substitute for a particular human expert task because AI has certain limitations in dealing with the relational aspects of expert tasks. Namely, AI cannot consider tacit data that are outside its available scope (opacity challenge), has difficulties adjusting its advice according to the audience

context (translation challenge), and cannot take responsibility for its advice to others (accountability challenge; Pakarinen and Huising, 2023). Due to these limitations, the effectiveness of an AI solution depends on data availability and professionals' interactions, and thus can vary significantly according to the professional service context (Lebovitz et al., 2022).

Third, AI adoption in professional services can involve professional identity change and cultural transformation, because AI can change professionals' roles and required expertise. As AI automates certain tasks, professionals need to shift their focus to higher-value-added tasks and become able to leverage AI in the remaining tasks (Raisch and Krakowski, 2021). This shakes professionals' role identity—self-recognition of "who we are" and "what we do"—and thus may cause some professionals to resist the change (Goto, 2021).

Knowledge of how these AI adoption challenges can be overcome in organizations, particularly PSFs, remains scarce. With the inquiry into service R&D in PSFs, this study also addresses this important understudied issue for theory and practice.

3. Methodology

The present study is based on an exploratory case study methodology (Yin, 2009), drawing on "extreme" cases of PSFs' incorporation of service R&D: cases where PSFs established and operated a new organizational function to centrally manage innovations in particular areas of the firm's interests. Theoretical sampling (Eisenhardt and Graebner, 2007) was applied to enable investigation of the Big Four Japanese audit firms' innovation process in their external audit services at their Tokyo headquarters in the 2010s, to incorporate AI.

3.1. The case context

The external audit is globally dominated by four groups of audit firms, commonly known as the "Big Four": KPMG, Ernst & Young (EY), Deloitte Touche Tohmatsu, and PricewaterhouseCoopers (PwC). In Japan,[3] their local member firms consist of the top four large-sized audit firms: Ernst & Young ShinNihon LLC (EY ShinNihon), KPMG AZSA LLC (KPMG AZSA), Deloitte Touche Tohmatsu LLC (Deloitte Tohmatsu), and PricewaterhouseCoopers Aarata LLC (PwC Aarata).[4] In 2017, the local Big Four firms had more than 90 % of the domestic market share of external auditing for listed companies in terms of the market cap of clients (Financial Services Agency, 2021). They had considerable financial and human capital resources, as shown in Table 1.

The case country was similar to other major OECD countries such as the USA, the UK, Australia, and Germany in that (a) the audit profession had long established its professional practices, (b) external auditing followed the same International Standards on Auditing (ISA), (c) the external auditing market was dominated by international group firms (the Big Four), and (d) leading firms had sufficient size and resources that enabled proactive development of some technological solutions by themselves. Although these firms had enjoyed their dominance in the established professional jurisdiction, they faced a loss of public trust in the profession due to continuing major incidents of accounting fraud (Mueller et al., 2015) and speculations of potential technological substitution of their work by the rise of new technologies, AI in particular (Frey and Osborne, 2017).[5] Aligning with their global group initiatives of incorporating digital technologies into their core auditing services to improve audit quality and address concerns for the future of the profession, these firms launched new organizational units and promoted their internal initiatives to innovate their external audit services with AI in the mid-2010s. There were some standardized basic digital tools for auditing that each of the four global groups had developed centrally and that the member firms mandatorily adopted (Table 2).[6] However, AI was out of the scope of those common global tools. Thus, the service R&D activities were autonomously initiated and managed by the member firms.[7]

At the end of 2019, as a result of those initiatives, the firms developed and adopted a broad range of new analytical solutions for their audit tasks with AI. Although their client needs varied, all the Big Four firms proactively promoted these innovations in their publications targeting their clients.

3.2. Data collection

The data were collected using three approaches. First, public literature concerning AI and the Big Four firms published from 2012 to 2020 was collected. As summarized in Table 3, this included (a) reports, press releases, brochures, a video, and magazine articles authored by the case firm auditors; (b) reports, brochures, videos, and magazine articles authored by domestic and other professional associations, and (c) other domestic newspapers (Nikkei) and business articles (e.g., Nikkei Big Data) on the topic.

Second, 68 face-to-face interviews with the local Big Four firms were conducted at three points in time: June–September 2017, July–December 2018, and October 2019–January 2020.[8] Each interview lasted 67 min on average, and 54 of these interviews were audio-recorded and

[3] Today's accountant and audit system in Japan began with the Certified Public Accountant (CPA) Law of 1948. In 1951, to ensure the reliability of financial statements in the securities market, the external audit by CPAs started based on the Securities and Exchange Act. In 1966, the current audit firm system was introduced. External audits have been the exclusive business of CPAs and their audit firms.

[4] For brevity, the present paper uses abbreviations of each firm commonly used locally (in parentheses). There is another smaller local PwC member firm: PricewaterhouseCoopers Kyoto (PwC Kyoto). The firm's operation and ownership have been independent of PwC Aarata's. PwC Kyoto ranks among the five mid-tier audit firms. This segment of audit firms is much less advanced in adopting AI and data analytics than the four large-sized firms (Financial Services Agency, 2021). Thus, this study focuses on the top four large-sized firms.

[5] The use and influences of AI and other advanced technologies in established professions have long been debated (e.g., Abbott, 1988).

[6] The global membership had the following characteristics. On the one hand, the case firms are autonomous national entities without capital ties with other member firms. They are owned solely by domestic auditors (Partners), and there are no parent-subsidiary relationships.On the other hand, these firms have agreements with each global group as a member of the global networks. The membership involves five common practices that member firms must follow. First, it allows member firms to use the same logo and brand of the global network. Second, member firms share information about audit markets and introduce clients to each other. Third, the global group sets audit standards and procedures for member firms. Fourth, the global group reviews the quality of audits in member firms. Fifth, the global group provides audit manuals and audit tools developed by the global headquarters. Although these tools involved some data analytics functions, the focus of service R&D activities in this case was the more advanced ones outside the standard tools.

[7] The case firms did not explicitly use the term "service R&D" in their internal and external communications. The only exception was when the researcher asked about the potential relevance of and similarity with R&D prevalent in the manufacturing sector. The leading partners in all four firms acknowledged in the interviews that their activities could be associated with "R&D of services." Therefore, the use of "service R&D" in the present study's findings was a scientific abstraction by the researcher based on the observed fit between the phenomenon and theoretical concept.

[8] The firms cooperated with this study on the condition that the intervention was purely for academic interest. All interviewees were informed about this agreement and knew that the interviews were solely for academic research. The researcher's contact with the firms was limited to interviews and follow-up exchanges with key staff who coordinated the interviews to clarify interview findings. No firms received advice on innovations or information about other firms. Because of this, the role of the researcher was that of an external observer, and the influence of research intervention on the firms was minimal.

Table 1
Overview of the case firms.

	Ernst & Young ShinNihon LLC (EY ShinNihon)	KPMG AZSA LLC (KPMG AZSA)	Deloitte Touche Tohmatsu LLC (Deloitte Tohmatsu)	PricewaterhouseCoopers Aarata LLC (PwC Aarata)
Global network	Ernst & Young Global Limited (EY)	KPMG International Cooperative (KPMG)	Deloitte Touche Tohmatsu Limited (DTTL)	PricewaterhouseCoopers International Limited (PwC)
Membership start year	2003	2003	1990	2006
Audit firm revenue (Mil Yen, 2018)	98,941	97,121	104,703	45,622
Audit firm staff (2018)	5578	6182	6787	3162
Headquarters	Tokyo	Tokyo	Tokyo	Tokyo

Note: The staff number of EY ShinNihon is as of July 1. That of Deloitte Tohmatsu is as of May 31. Other figures are as of June 30.
Source: Public inspection reports and other published reports of the case firms.

Table 2
Key audit tools developed by and mandated within global groups.

Tool category	Tool name (firm)	Function
Electronic working papers system	"EY Canvas" (EY ShinNihon) "eAudIT" (KPMG AZSA) "Magnia" (Deloitte Tohmatsu) "Aura" (PwC Aarata)	An online platform that enables auditors to centrally manage the work progress of the entire audit team and to create audit documentation according to the audit process and standards.
CAAT (computer assisted audit techniques)	"EY Helix" (EY ShinNihon) "KPMG Clara" (KPMG AZSA) "Illumia" (Deloitte Tohmatsu) "Halo" (PwC Aarata)	A non-AI data analytics and visualization tool to identify high-risk matters based on statistical methods in pre-programmed ways and to visualize the outputs.
Audit data transfer system	"EY Canvas Client Portal" (EY ShinNihon) "KPMG Central" (KPMG AZSA) "Deloitte Connect" (Deloitte Tohmatsu) "Connect" (PwC Aarata)	An online platform that secures online file sharing among the auditee and auditors.
Knowledge portal	"EY Atlas" (EY ShinNihon) "Cognia" (Deloitte Tohmatsu)	A global portal site that provides various knowledge and audit support tools.

Note: Detailed functions of each tool vary by group.
Source: Published reports of the case firms.

transcribed verbatim, while the remaining 14 interviews were recorded in intensive notes taken during and after the interviews.[9] Table 4 shows the details of the interviews.

In the first phase (June–September 2017), the first three open-ended

[9] The present study adopted the following design to minimize the potential influences of cross-cultural differences on data collection and interpretation (e.g., a lack of rapport with informers, cultural bias that hinders interpretations of nuances, interviewees' hesitancy to disclose delicate information to outsiders, and their impression management for social desirability). First, the interviews were conducted by a Japanese native-speaking researcher. All the interviews were conducted in the local language (Japanese), except one in English, with two Partners who were part-time advisors on the latest technological trends to the service R&D at Firm D (#35). The quotations presented in the current paper have been translated into English from Japanese. Second, research collaboration was initiated from the agreement with the senior management of the case firms, the researcher concluded formal NDAs when needed, and the interviews were conducted on the condition that the names of the firms and individuals would be anonymized. These provided interviewees with psychological safety in their disclosing information. Third, follow-up exchanges were conducted when clarification was needed.

Table 3
Overview of literature data sources.

Type	Source	Content	Amount (number of items)	Amount (pages)
(a) Local Big Four firms' publications	EY ShinNihon	Public inspection reports ShinNihon Audit Quality Reports Press releases Media articles (e.g., "Information Sensor") Video (Youtube)	38	895
	KPMG AZSA	Public inspection reports AZSA Quality Press releases Reports (e.g., "KPMG Insight") Media article ("Kigyo Kaikei")	23	765
	Deloitte Tohmatsu	Public inspection reports and Annual Review Quality Reports Press releases Brochures (e.g., "Audit Analytics") Media articles (e.g., "Kansa-yaku")	36	887
	PwC Aarata	Public inspection reports Transparency Reports Press releases Reports (e.g., "PwC's view")	20	661
(b) Professional associations' publications	JICPA	Annual reports, Institutional profile Press release Reports (e.g., "IT committee reports") Media articles (e.g., "Kaikei Kansa Journal") Videos (JICPA website)	18	386
	Other professional associations	IFAC report IAASB reports AICPA reports	6	275
(c) Domestic media articles	Newspapers Business magazines	Newspaper articles (Nikkei) and magazine articles (e.g., Nikkei Big Data)	51	78
		Total:	192	3947

Note: Videos are not included in "Amount (pages)."

Table 4
Details of interviews.

Audit firm	Number of interviews				Number of interviewees				Total hours
	Total	2017	2018	2019–20	Total	Partner, Director	Senior Manager, Manager, Assistant Manager, Senior Associate	Non-auditor advisors	
Firm A	22	15	1	6	16	5	9	2	25
Firm B	8	3	1	4	11	4	5	2	10
Firm C	24	0	11	13	23	11	10	2	24
Firm D	14	0	9	5	12	3	6	3	17
Total	68	18	22	28	62	23	30	9	76

Note: The firms' order follows the order of access in this research.

and non-audio-recorded interviews (#1–3, with Firm A and B) were used to develop the research design and an interview question guideline (Table 5).

These interviews centered around the backgrounds of some Big Four local firms' press releases on launching new organization units for applying "AI" to auditing. The guideline was applied to the subsequent 15 interviews with Firms A and B (#4–18). These interviews covered all question categories but flexibly expanded to more detailed questions when possible. The interviews prioritized "(c) Professional association" when the interviewees had part-time transfer experiences to the national professional association (the Japanese Institute of Certified Public Accountants (JICPA)).

In the second phase (July–December 2018), the guideline was applied to the 22 interviews with four firms (#19–40) in the same way as in the first phase. In the third phase (October 2019–January 2020), the first four interviews (#41–44, with the four firms) were open-ended and not audio-recorded, focusing on the changes from the previous year. These discussions were used to set the focus of the interviews that followed (#45–68). The question guideline was applied to the subsequent 24 interviews (#45–68), but the focus of the questions shifted to "(a) The firm" in "B. The initiative," which suggested significant changes from the previous year in #41–44.[10]

The interview sampling logic was as follows. In the first and second phases (2017–18), the interviews focused on core members and advisors of the service R&D organizational units who directly engaged in the function. This was necessary because the activities of the newly created service R&D units were confidential, even within the firms, and thus, other auditors had little knowledge and opinions on the topic. The diversity of interviewees' rank (from Partners to Senior Associate) enhanced the double-checking of the process from diverse views. In the third-phase interviews (2019–2020), when the initiatives began to engage frontline auditors for implementation, the interviewees were expanded to frontline auditors who were part-time service R&D members in charge of frontline implementation (#48, 49, 51–55, 59), as well as those who were nonmembers (#46, 56).

Third, besides the publicly available literature and interviews, two types of internal data were accessed for triangulation. The first was internal materials that were presented in some interviews at all of the case firms.[11] The contents of these materials supported what the interviewees explained, showing no significant deviation from the public information. These materials could not be shared as files with the researcher for confidentiality reasons. The second was the sample documents of weekly meetings collected at Firm A. The documents were prepared and used for their weekly meetings of their service R&D unit in 2017. This material showed that the service R&D managed weekly information sharing and discussion sessions for service R&D organization members by setting agendas, facilitating sessions, and allocating roles.

Table 5
Interview question guideline.

Category	Key questions
A. The interviewee	What is your career background and role in the initiative of AI and audit?
B. The initiative	
(a) The firm	
Objectives	What were the objectives for the firm to start the initiative?
Processes and outputs	How did the initiative progress? What were the outputs?
Impacts	What kind of changes did the initiative cause?
Reactions	What were the reactions of the stakeholders in the firm?
Challenges	What were (will be) the challenges for the initiative to progress?
(b) Clients	What were the reactions of the clients?
(c) Professional association	What roles did the local professional association play?
(d) Global group	What roles did the Big Four global group and headquarters play?

3.3. Data analysis

The data were analyzed with the following iterative steps (Yin, 2009). First, a within-case analysis was conducted by developing case histories for each firm based on the literature and interviews regarding what was observed to have happened and in what order. In this step, the rich literature data provided detailed information about each firm's process history and innovation outcomes.[12]

Second, the case histories were compared across firms. The cross-case comparison revealed that the four case firms showed a highly similar pattern in their organizational change and innovation activities with only minor variance in detailed aspects. Thus, the subsequent analysis focused on the commonalities of these four firms, instead of comparing the differences (Eisenhardt, 1989).

Third, a more detailed analysis of each firm was conducted with a

[10] As the process of AI adoption involved a variety of newly developed software solutions, the interviewer clarified the focal tool that the interviewers were talking about when necessary.

[11] Those materials included (a) firm management meeting minutes in which the firm discussed and approved of their service R&D organization reformation, (b) presentation documents to explain their new tools for their clients, (c) presentation documents to explain their new tools/initiatives for their CPAs, (d) presentation documents that explained new internal skill training for their CPAs, and (e) presentation documents that explained their future vision for their CPAs. In addition, the interviewees showed (f) their intranet websites that listed their available AI and data analytics solutions for their CPAs, and (g) short videos created for their CPAs that visualized their vision of future auditing.

[12] Specifically, the case firm reports (e.g., inspection reports) and press releases showed organizational charts, innovation initiatives, developed tools, and innovation progress. The media articles written by the auditors of the case firms revealed their service R&D organizations' initiatives and underlying considerations. Other literature data (professional association publications and media articles) informed about the initiatives by the professional association and the background of how the auditors and society perceived the progress of AI adoption.

two-step coding approach (Gioia et al., 2013). This method is a widely used approach "designed to bring 'qualitative rigor' to the conduct and presentation of inductive research" (Gioia et al., 2013, p. 15). This methodology has been adopted in a wide range of qualitative studies involving a large volume of interviews (e.g., Kapturkiewicz, 2022) because it is systematic and allows for a deep understanding of informants' experiences. "In vivo" coding was initially conducted to capture what the informants intended to convey. All items in the first-order categories had support in all four firms. This was followed by the second-order themes that were induced to capture common themes across the first-order categories. The second-order themes were thematically synthesized into aggregate dimensions. As a result, the analysis developed a data structure in which all the first-order categories were supported by evidence in all firm cases (Fig. 1).

The following approaches were deployed throughout the analysis to improve validity and reliability (Yin, 2009, p. 41). The first was using qualitative data analysis software (NVivo) to facilitate iterative pattern matching and explanation building. The second was that multiple quotes or literature data were confirmed for each first-order category item for all four firms in coding the data. The third was that tentative interpretations and analysis results were shared, adjusted, and confirmed with key informants of the four firms several times in 2017–20 and 2022. In addition, triangulation was conducted with multiple data sources. The analysis continued until no discrepancies were observed between the analysis results and the informants' understanding, confirmed in post-interview interactions with the key contacts at the case firms. Rich literature data were used to supplement and verify the interview data on detailed organizational change, innovation initiatives, and available tools at different times.

A process model was developed on the way in which innovations enabled by service R&D unfolded in the case firms, here through the allocation of the second-order categories in the data structure to the phases in which each category was observed (Fig. 2).

4. Findings

The four firms successfully developed various solution tools with AI that were used for their external audit services by the end of 2019. Table 6 shows representative solution tools that were publicly announced.

The developed tools involved various AI software applications for cognition and analysis, such as image recognition, voice recognition, natural language processing, and machine learning for data analysis.[13] These solution tools were used in a wide range of auditing tasks throughout the auditing process to provide professional opinions and advice to clients.[14] More specifically, the tools could collect, transfer and process various forms of client data and thus substitute or support human decisions by making predictions, identifying abnormalities, and automating audit tasks.

The data showed two country-specific contextual factors that might have increased the need for customized solution development in some task areas. First, standardized enterprise resource planning (ERP) systems such as SAP were less diffused among business firms, and most companies made significant customizations when they used one (METI, 2018). This deteriorated the effectiveness of automation solutions focused on audit clients equipped with integrated ERP systems (e.g., "KAAP" in KPMG). Second, the local language influenced the effectiveness of some NLP solutions that operated only in English (e.g., "Argus" in Deloitte).

This chapter elaborates on the findings about how these innovations were realized, each phase in order, with a particular focus on the three dimensions that emerged from the data analysis.

4.1. Phase 1: plan and preparation

4.1.1. Organizational change

In the beginning, the four firms engaged in preparing for *launching a service R&D organizational unit* that focused on adopting AI and innovating their services. Specifically, Deloitte Tohmatsu first launched "Deloitte Analytics" in 2012, an organizational unit involving auditors and other non-auditor experts (e.g., data scientists), to provide services using AI and data analytics to various clients. Leveraging their expertise, "Audit Innovation Promotion" team was created in its Audit Division under the supervision of the firm's "Audit Innovation Steering Committee," which directly reported to its Executive Committee. The other three firms followed the same path of creating an innovation organizational unit for researching and implementing AI in auditing ("Next Generation Audit Technology" unit within Quality Assurance HQ in KPMG AZSA in 2014, "Assurance Innovation Lab" as a virtual organization in EY ShinNihon in 2016, and "AI Audit Lab" under the Executive Committee of PwC Aarata in 2016). These organizational units, managed by several auditor Partners, assigned a small number of dedicated core staff (mainly Senior Manager or Manager-class auditors) to plan and manage their activities. These organizational units also involved other internal and external technology experts as advisors when necessary. They were supported by part-time members who were middle- or junior-class auditors with their interest and/or expertise in digitalization and new technologies. As a Senior Manager (Firm A) who was a founding member commented, the introduction of an organizational unit dedicated to innovation with technology was a new approach for the firm:

> "We do have some teams that support pilot tests and adoption of auditing tools which our global group developed. But, there has never been a department in Japan that researches and develops technologies and tools for audit business transformation."

4.1.2. Service R&D activities

In this phase, the newly created organizational units engaged in *planning and managing initiatives* for innovations with AI technologies. Their primary objective was to study the potential of adopting AI in auditing to improve the quality and productivity of audit tasks. Accounting research has revealed that AI adoption requires evaluating and prioritizing audit tasks according to the suitability for the AI adoption (Kokina and Davenport, 2017). Following the theory and leveraging their knowledge as auditors, the organizational units explored target audit task areas in which the auditors perceived significant room for improvement, with the support of advisors in estimating AI technology capacity and feasibility. They assigned small sub-teams, typically several staff members, to each prioritized task area. The organization units also designed their project structure and processes, such as objectives, reporting lines, and periodical meetings to monitor the progress in sub-teams and to reorganize the task area priority and team composition when necessary. A comment from a Partner at Firm D demonstrated their approach in this phase that focused on designing and planning the overall project before serious investments:

> "What [the service R&D organizational unit] is doing is strategizing, such as how far the digital strategy should be advanced in the next three years, what should be the shape of the future auditing, and how many clients will apply the future audit. …Each team [in the service R&D unit] owns a particular issue, breaks down the strategy, plans what to do in the next three years, and advances the initiative."

[13] Non-AI data analytics solutions with business intelligence tools (e.g., Tableau, Alteryx, and QlikView), Robotic process automation (RPA) tools, and other digital applications were often used jointly with AI tools in the latter phases of this innovation process, but the findings here focused on AI.

[14] The service R&D organizations focused on the work of audit professionals in audit projects, not on the work of administrative support staff (e.g., human resources and public relations) in the audit firms.

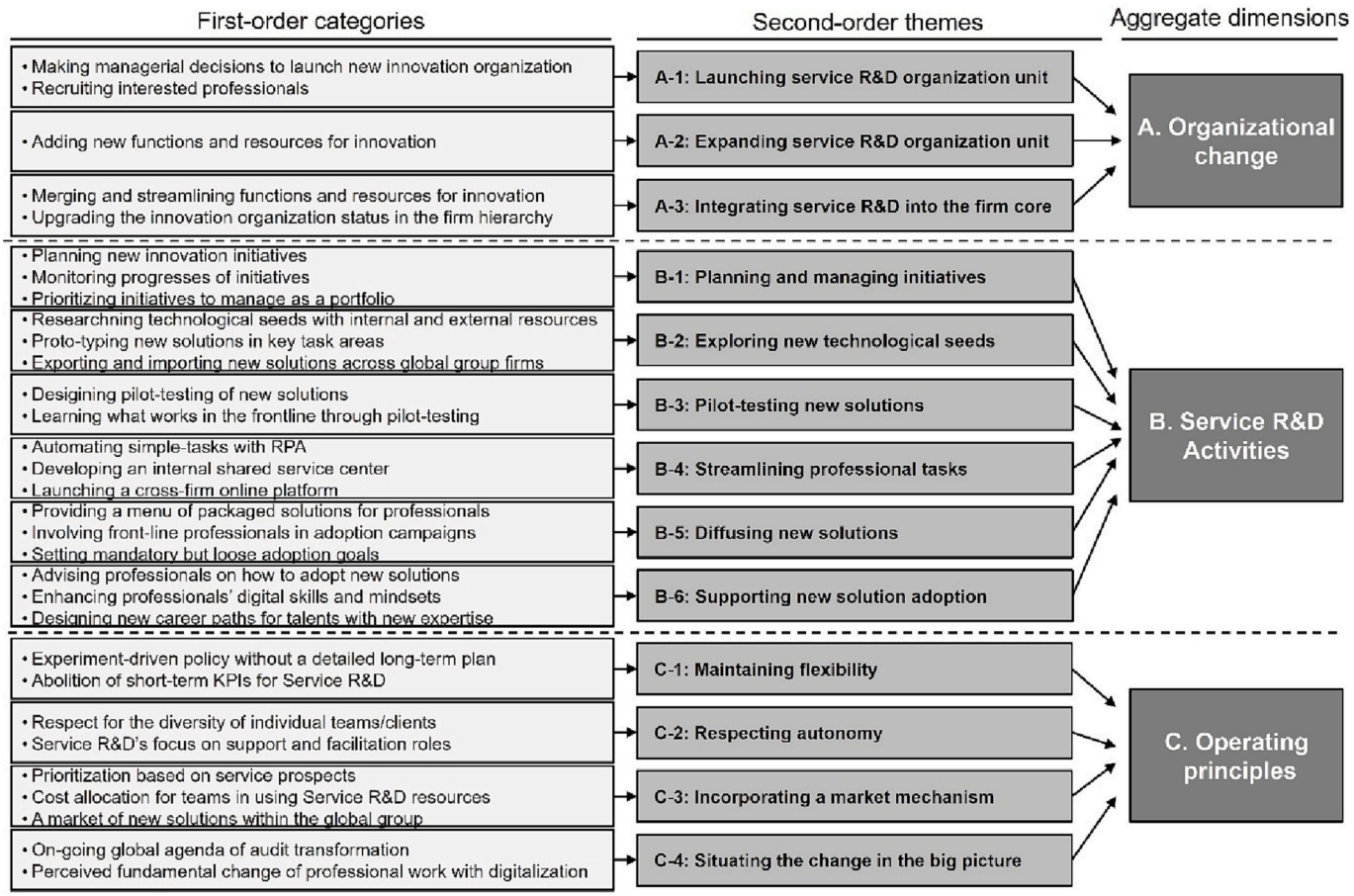

Fig. 1. Data structure.

4.1.3. Operating principles

In the planning activities, *maintaining flexibility* was the primary concern for the service R&D organizational units. Specifically, their activities in this phase showed two particular features. First, they adopted an explorative policy without a detailed long-term plan. Although they had to develop certain strategic plans, the time spans of those plans were intentionally abstract so that they could reflect changes in external environments and technological advancement. The logic behind such obscure long-term plans was the perceived unknowability of the future of advancing technology. As a Partner at Firm A commented, "there [was] no strict plan" because "after all, no one knows the future in this area" (Firm A). Instead, they preferred "always continuing pivoting" (Firm D). Second, these firms did not set short-term key performance indicators (KPIs) for service R&D. All firms intentionally left the goal of the new organizational unit highly abstract. They thought that KPIs could enhance a short-term orientation and hinder long-term success when technological advancement was uncertain. Thus, the new organizational units prioritized their ability to flexibly adjust their portfolio and contents of activities to maintain their alignment with the unknown future. A Senior Manager at Firm A commented on their intention to maintain flexibility:

> "We haven't set a specific goal about what by when. …Because there are quite a few things we don't know about, particularly the degree of technological advancement. …Of course, we wanted to launch some tools as soon as possible, but we thought we should not make such a promise."

4.2. Phase 2: ideation-focused

4.2.1. Organizational change

These service R&D organizational units obtained more official upgraded statuses following their successful launches. In this phase, they expanded their staff sizes by creating a broader range of new functions in their organization units. Fig. 3 summarizes the organizational changes in the four firms in the late 2010s.

For example, two years after its launch, "AI Audit Lab" at PwC Aarata expanded to form the core of its "Planning and Management Division" as of July 2018. The division's core consisted of two departments: "Audit Task Transformation Promotion" and "AI Audit Lab." The former focused on overall planning, project management, and negotiations with key stakeholders, while the latter continued AI technology research and development. The division also acquired "Technical Competency Center" in July 2019. This shared service center, launched initially as the "Audit Assistant Office" in October 2017, handled non-expert tasks in auditing using non-CPA clerical staff. Although the specific organization names and creation dates varied, other firms followed a similar path of service R&D organizational change involving staff increase, functional expansion, and the development of a shared service function. In this phase, the service R&D organizational units proactively hired external talents with data science and other related backgrounds to expand their AI technology research and development capacity. A Senior Manager at Firm A summarized the organizational change in this phase:

> "The organizational unit has been upgraded as a BU [business unit], same as other units [that focus on specific client industries] such as the financial services department or the manufacturing department. It expanded to that scale with an executive officer in charge. In short, you can summarize the organizational change [surrounding the

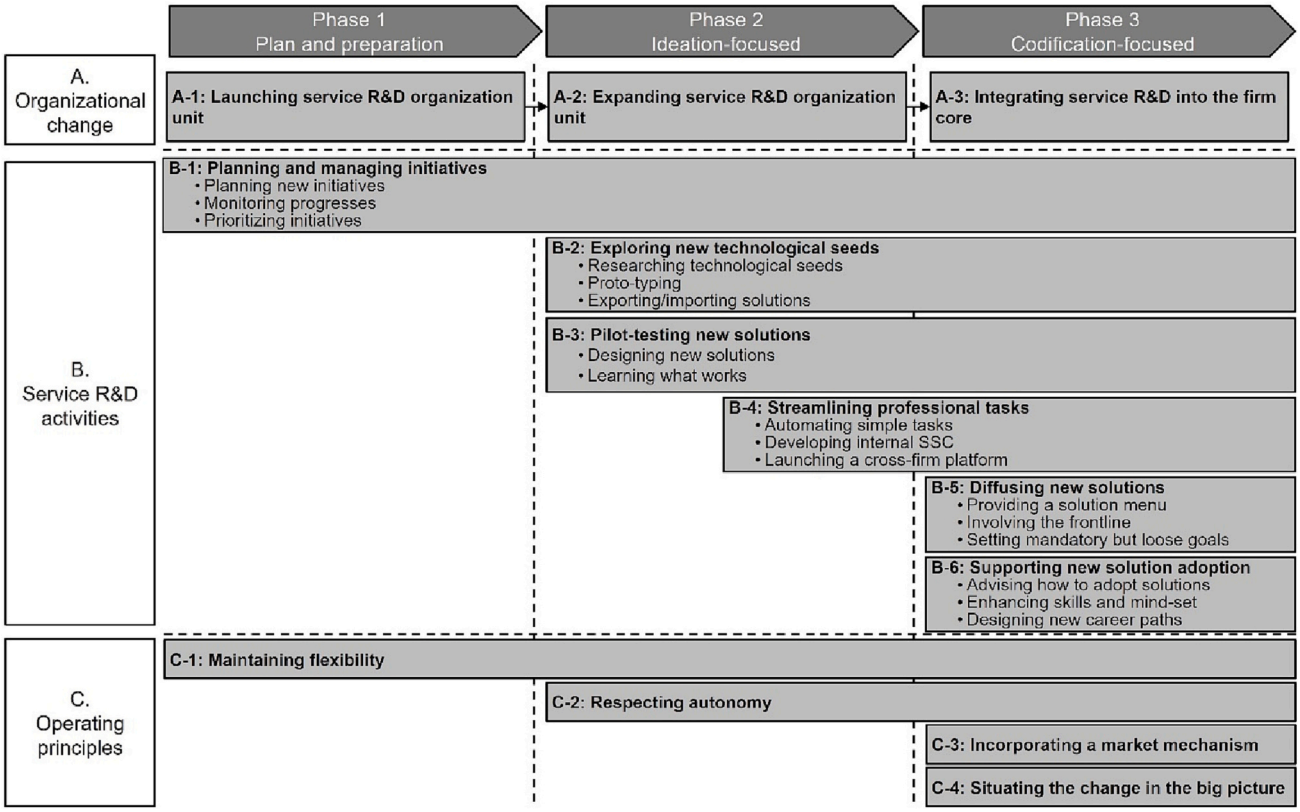

Fig. 2. Process model.

service R&D] as continuous expansion and upgrading [in this phase]."

4.2.2. Service R&D activities

In this phase, the main activities of the service R&D focused on the ideation of innovative ways of using AI in auditing. Three types of service R&D activities were observed across the firms.

First, the service R&D organizational units engaged in *exploring new technological seeds*. They researched available technological solutions related to AI. In their search, they contacted various actors, such as management consultants and IT experts in their groups in Japan, as well as AI solution vendors and university researchers. Some external discussions led to formal research alliances in specified task areas; for example, EY ShinNihon collaborated with a scholar at the University of Tokyo on fraud accounting forecasting models using machine learning, which was announced in June 2016. These discussions with various actors informed them of general AI capacity and typical applications, thus sharpening their prioritization of which audit task areas to apply AI. Sub-teams were assigned to develop prototype software solutions in the specified priority audit task areas, sometimes with support from external vendors and alliance partners.

Simultaneously, members of the service R&D units explored technological seeds internationally within their groups. They used both official and unofficial channels. Sometimes, the service R&D staff used their global group intranets, which allowed individual professionals to search for and find technological tools adopted in their group firms outside the country. More frequently, they used their personal networks with auditors within their same global groups to exchange ideas on the latest developments in applied AI, so that they could leverage knowledge and export or import AI solutions when available. A Partner at Firm C commented on their iterative exploration from a variety of knowledge sources:

> "Since we are not engineers, we discover many unexpected hurdles through discussions with various AI experts and vendors. What we originally wanted was not possible, or it was not effective even if it was possible, and so on. I feel as if I'm hitting various walls over and over again. Also, in collaborating with our global group firms, we often find more advanced solutions than ours in another office. Thus we sometimes stop our initiative in that task area and adopt other offices' tools."

Second, the service R&D units engaged in *pilot testing new solutions* in prioritized audit task areas in collaboration with ongoing audit client projects. They organized pilot tests to learn what would work and what would not in actual auditing projects.

Although many pilot tests showed successful results, some projects demonstrated difficulties in applying AI to auditing. The first was the difficulty of preparing sufficient data for the algorithms. Due to confidentiality concerns, cross-client data use was limited. In addition, because of the lack of data format consistency and data integration at some clients, the available data were sometimes further limited. These issues sometimes made important data opaque for algorithms, thus deteriorating their analysis quality. The second difficulty was interpreting the analysis results according to the client-specific contexts. For example, the AI solution that used machine learning to detect anomalies in a general ledger was expected to be an automation tool. However, an abnormal journal entry for one firm is not necessarily inappropriate for another firm because journal entry customs could vary by the firm to some extent. This made the interpretation of the analysis results less automatic, requiring translation adjusted to the client's context. The third difficulty was the accountability of the analysis results. In the same example of the abnormal journal entry detector, it was difficult to leave the task entirely to the machine because the auditors were responsible for evaluations and reasoning, but the algorithm was black-boxed for the auditors. Finally, operation costs were a hurdle in other cases. For example, several firms conducted pilot tests of drones equipped with

Table 6
Key solution tools developed in the case firms.

Category	Tool[a]	Key technology (source)	Usage
1. Solutions for individual audit tasks[b]			
Audit planning-Risk assessment	"Web Dolphin" (EY ShinNihon) "Fraud risk scoring" (KPMG AZSA) "AI-risk assessment system" (PwC Aarata)	Machine learning (ML) (global group, or internal development with university researchers)	Extracting high-risk account items and firms based on securities reports, to support prioritization in auditing.
Substantive test-Observation	"Inventory inspection with drones" (EY ShinNihon)	Drone, image recognition, ML (internally developed)	Utilizing drones with cameras for inspections of physical inventories.
Substantive test-Vouching	"Smart audit platform" (PwC Aarata)	NLP/OCR, ML, RPA (global group)	Automatic reconciliation of specific documents (e.g., invoices).
	"Argus" (Deloitte Tohmatsu), "Automatic contract verification" (PwC Aarata)	OCR, NLP, ML (global group)	Extracting and organizing the necessary information from the auditee's contracts.
Substantive test-Analytical procedures	"Profit forecast" (Deloitte Tohmatsu)	ML (internally developed)	Forecasting profits by stores to evaluate the validity of the auditee's estimations.
	"Bad debt forecast" (Deloitte Tohmatsu)	NLP, ML (internally developed)	Predicting the risk of bad debts from the text data of visits by the auditee's sales reps to evaluate the validity of the auditee's estimations.
	"Project deficit forecast" (KPMG AZSA) "Project profitability forecast" (Deloitte Tohmatsu)	ML or Non-AI data analytics with Business intelligence tool (internally developed)	Predicting project profitability from various variables at a construction company to evaluate the validity of the auditee's estimations.
Substantive test-Journal entry testing	"Helix GLAD" (EY ShinNihon) "Abnormal journal entry detection" (KPMG AZSA) "Magnet" "Spotlight" (Deloitte Tohmatsu) "GL.ai" (PwC Aarata)	ML or Non-AI data analytics with Business intelligence tool (global group, or internal development, or internal development with university researchers)	Filtering out unusual patterns of transactions in journal data as potentially fraudulent.
2. Solutions for specific clients' information systems or account items			
For specific account items	"Cash.AI" (PwC Aarata)	ML, RPA (global group)	Automatically completing audit procedures for cash items (currency conversion, deposit reconciliation, etc.).
3. Solutions for general use throughout auditing			
Knowledge sharing	"Komei" (KPMG AZSA)	NLP, ML (Watson, IBM Japan)	A chatbot for auditors on FAQs (frequently asked questions) in auditing.
Data processing	"Automatic meeting minutes creation" (KPMG AZSA)	Voice recognition (internally developed)	Converting meeting recordings into text data automatically.

[a] The tools listed are not exhaustive and are based on public information.
[b] The process category classification follows PwC Aarata's. (PwC Aarata's report published in 2018: "Kansa no henkaku: Donoyo ni AI ga kansa wo kaerunoka (Audit transformation: How AI will transform accounting audit)." https://www.pwc.com/jp/ja/knowledge/thoughtleadership/2018/assets/pdf/audit-change1804.pdf (accessed on 1 December, 2022).)
Sources: Published reports and websites of the case firms, confirmed by review discussions.

cameras with advanced image analysis capacity for some audit tasks, such as physical inventory auditing in warehouses. Although the solution was proven to work, the high costs of drone pilots and machines made the solution less attractive to some firms. These experiments successfully developed various audit software tools customized to specific auditing tasks. However, the tools sometimes had limitations in practical use.

Throughout the process, the role of external partners was ancillary: providing technical knowledge and supporting tool development upon request by the service R&D units. As there were practically no packaged solutions applicable to auditing, the service R&D units needed to develop AI solutions by customizing external vendors' available algorithms or developing new algorithms using available online libraries. They screened external partners that best fit each selected task area. In a typical case of collaborative tool development, the external partner provided advice on tool design from the technological viewpoint to fulfill specified needs, and developed algorithms, while the service R&D units selected the partner, summarized users' requirements, facilitated data management and pilot tests, and collected auditors' feedback. In some cases, the service R&D units developed tools themselves when they had advice from university scholars or after they hired data scientists for their teams.

The development processes were monitored through periodical member meetings in the service R&D organization units. The service R&D units often reorganized their portfolios of prioritized task areas and pilot tests, and thus sub-teams were flexibly created and abandoned according to their progress and experiment outcomes. A Manager at Firm B described their intention to use pilot testing proactively:

> "We can't make a perfect solution from the beginning, so we ask users to test it, listen carefully to their requests for improvements, and fix the ones that can be fixed. We used such a cycle. Since auditors need to follow precise auditing protocols, general-purpose software does not fit. We are continuously improving what features should be added to meet the auditing needs, which requires many users' support."

Third, after establishing the cycle of new solution exploration and pilot testing, the case firms engaged in *streamlining professional tasks* to improve efficiency so that the auditors could have sufficient time to adopt new tools in the future. This stream of activities involved three

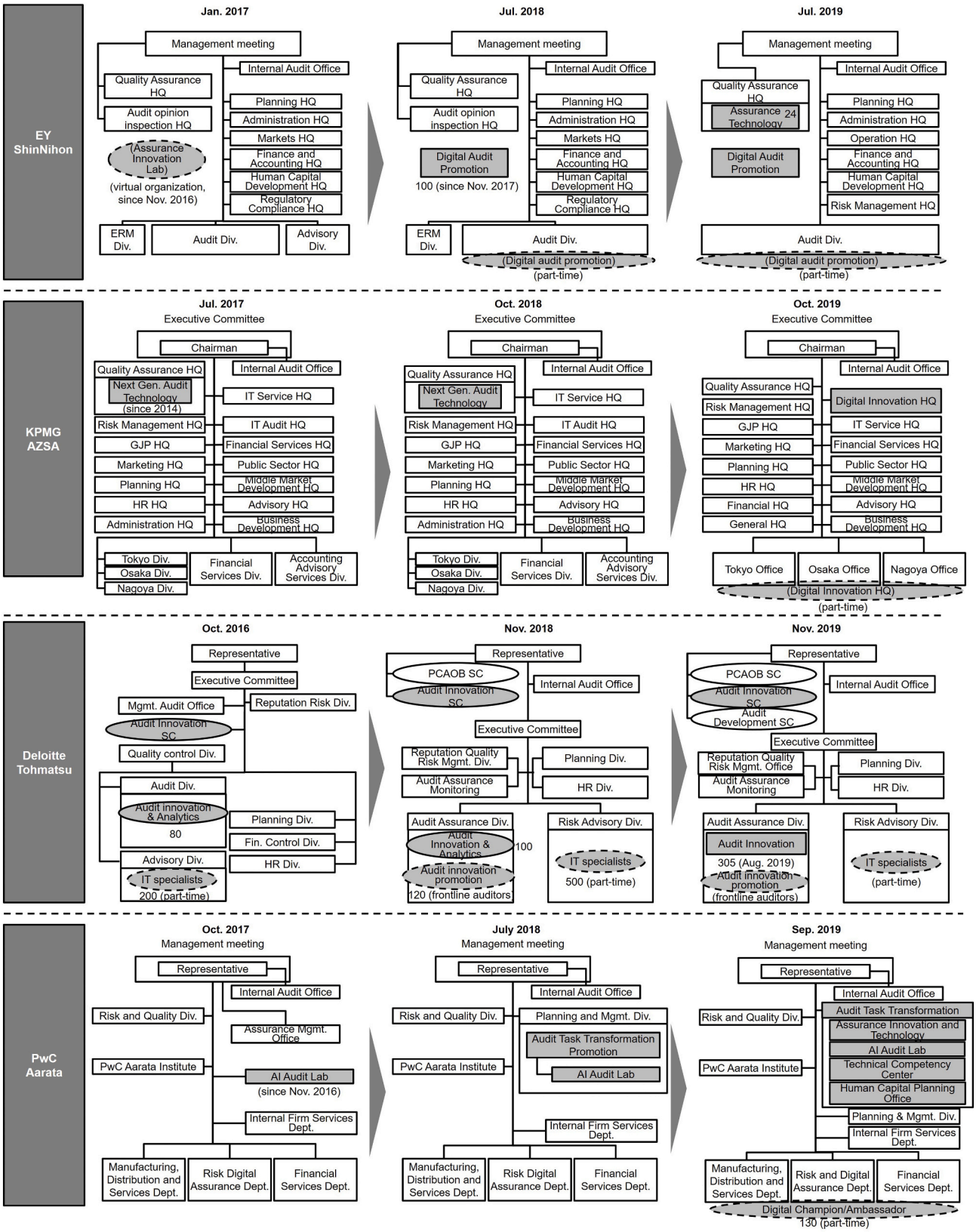

Fig. 3. Organization charts of the case firms.
Note: Shaded areas indicate the service R&D function. Numbers indicate the number of staff.
Source: Published reports and websites of the case firms.

initiatives. The first was automating simple audit tasks using available technologies, particularly robotic process automation (RPA) tools. In this phase, the firms integrated their internal RPA expertise into service R&D so that frontline auditors could smoothly use RPA tools. The second initiative was developing internal shared service centers. The shared service centers could support auditors in non-expert simple tasks upon request in exchange for internal time charges. A Manager at Firm A explained the need for such a shared service center:

> "Until today, accountants have done everything. If our firm were a hospital, it would be like doctors are doing all the work that nurses and medical office staff are supposed to do. Literally, accountants were doing everything from A to Z. We think we should change that first. Accountants really should focus on areas that only accountants can do and add value. Other tasks can be automated or dealt with by non-auditor audit assistants like nurses in hospitals. That is our approach."

The third approach was launching a cross-firm platform for a certain category of simple audit tasks. Specifically, the four firms established a consortium on a joint platform for a balance confirmation system in February 2018.[15] The consortium, supervised by the JICPA, resulted in the launch of a joint venture of the four firms—Audit Confirmation Center LLC—in December 2019. The center digitized a simple but time-consuming task (balance confirmation), handled more than 200,000 issues in FY 2021, and was also made available to other non-Big Four audit firms.[16] The joint venture collected a fee per use from all the users, including the Big Four firms.

Successor initiatives did not materialize during the observation period, but the collaboration played a symbolic role in representing the need for an industry-wide digital transformation. A Partner at Firm C shared their sense of urgency in this regard:

> "I think there is a movement to increase cross-firm collaborations starting with this joint platform. As an industry, we are far behind in the digital area. The entire audit industry needs to collaborate and deal with it. Otherwise, for example, new players such as IT vendors might take over the whole industry."

4.2.3. Operating principles

In these activities, the service R&D units continued to pay special attention to maintaining flexibility, mainly due to their frequent refocus of technological seed search and pilot tests. In this ideation phase, the members' core concern was *respecting* the professionals' *autonomy*. Specifically, the service R&D units regarded the diversity of contexts encountered by individual teams and clients as a critical input for innovation ideation. They perceived that the detailed auditing processes varied significantly by client and industry. Consequently, they allowed service R&D members and collaborating frontline auditors to design prototype solution tools autonomously. The service R&D process developed dozens of various AI solutions customized to specific small segments of auditing tasks, instead of a limited set of multi-purpose software tools that would apply to a wide range of auditing tasks. This approach, ideation coordinated by the central R&D organization but driven by individual professionals' needs, meant that the service R&D units identified themselves as a supporter and facilitator for the frontline auditors, rather than the owner and controller of the innovation. They focused on "what the pains of audit teams are and how AI tools can help solve those problems" (Firm B). A Manager at Firm B aptly commented on the significance of such an operating principle:

> "After all, each client has its own characteristics and different issues. So even if the audit procedure seems the same across clients at a glance, it actually can be completely different in all detailed procedures. Thus, we doubt if a unified solution could work…. Of course, it would be great if we could have certain packaged solutions. But we need more customized tools and a tailor-made approach to auditing. Perhaps, if we as a firm develop only one universal solution, we wouldn't be able to customize it to all clients later. So, we are working closely with each audit team."

4.3. Phase 3: codification-focused

4.3.1. Organizational change

After ideation-focused activities matured to provide a stock of prototype AI solution tools, the phase shifted to the implementation, or codification of innovation seeds. The case firms further changed their organizations by *integrating service R&D into the firm core*. Service R&D units were expanded further and integrated as larger organizational divisions, which were positioned as the core of their firm-wide continuous transformation and long-term strategic competitiveness quest (see Fig. 3). Specifically, Deloitte Tohmatsu assigned 120 frontline auditors to "Audit Innovation Promotion" team part-time to support the diffusion and further materialization of new tools as of November 2018. The firm integrated related functions into a new organizational section, "Audit Innovation," within the "Audit Assurance" division in 2019. This symbolized that the innovation activities were positioned as the core function of the audit business unit. PwC Aarata also upgraded its service R&D as an independent organizational section, "Audit Task Transformation." The scope of its function expanded to involve "Assurance Innovation and Technology" as innovation planning and management, "AI Audit Lab" as research and development, "Technical Competency Center" as shared service, as well as "Human Capital Planning Office" as strategic planning for future career models in the firm in 2019. It also assigned 130 frontline staff as "Digital Champions" and "Digital Ambassadors" part-time to facilitate the diffusion of digital auditing. Other firms followed the same organizational change; KMPG AZSA upgraded its service R&D as "Digital Innovation HQ" and assigned frontline auditors on a part-time basis in 2019, and EY ShinNihon upgraded its service R&D to a formal organizational unit, "Digital Audit Promotion" and assigned frontline staff on a part-time basis for innovation diffusion in 2018–2019.[17]

4.3.2. Service R&D activities

In this phase, the service R&D units continued researching new technological seeds and pilot-testing new AI solutions in several remaining task areas. They also continued to develop and expand their shared service centers. Furthermore, they shifted their focus of activities to codification in 2018–2019 to identify the way in which the new tools could be used in practice. The new service R&D activities involved two initiatives: *diffusing new solutions* and *supporting new solution adoption*. First, the case firms invested resources in diffusing pilot-tested AI tools

[15] The reason why this happened in this particular task was twofold. First, the task area was so simple (just checking whether two figures balance) that the audit firms perceived the task area as noncore, without any room for significant differentiation. Second, they perceived that developing and using four platforms would make little economic sense for themselves and their clients. As a result, collaboration in this area provided no perceived significant risks but opportunities for productivity improvement.

[16] The reason why it was made available to other audit firms was twofold. First, the JICPA asked the firms to make the platform open. This was because of its concern that smaller firms should not be left behind in digital transformation. Second, the Big Four firms also perceived that the excessive lack of digitalization (and resulting low-quality and inefficient audits) in smaller firms could deteriorate the reputation of auditing. Thus, supporting smaller firms in noncore tasks was not problematic for large firms.

[17] After the observation period, on July 1, 2020, EY ShinNihon established a new independent department, "Assurance Innovation," with 400 members directly under the CEO; the new department involved the auditors in the service R&D studied in this research.

within their firms. Specifically, each firm provided a menu of available AI tools on its intranet, so that frontline auditors could easily consider adopting them. The service R&D units also engaged frontline professionals in their internal diffusion campaigns. Those frontline professionals assigned to the diffusion support on a part-time basis periodically informed individual audit teams of the launch of new tools. They facilitated discussions between the central service R&D units and individual teams. In these diffusion activities, the case firms intentionally set loose goals for individual teams; the service R&D units did not specify which tools to adopt or in what way, but instead mandated that each audit team should adopt a minimum number of new tools (one or two in most firms), which those professionals themselves could choose. As a result, the firms successfully adopted these new tools. For example, Deloitte Tohmatsu announced that more than 96 % of their audit teams serving listed companies used some tools based on advanced analytics technologies, which it called "Audit Analytics",[18] in FY 2018–2019. Other firms also published their successful adoption of new tools in their reports.

Second, the service R&D units intensively supported individual audit teams' new solution adoption with the diffusion initiatives. Specifically, they provided one-on-one consulting on solutions to adopt in specific settings. The service R&D units typically set "Kick-off" meetings with each audit team at the beginning of each fiscal year. In those meetings, they discussed new solutions or approaches that could be applied to clients in the fiscal year and how the service R&D units could help the implementation. Some audit teams could apply pre-developed tools in the menu, while others needed further testing and customization with the service R&D units. The service R&D units also accepted ad hoc calls for support from audit teams during a fiscal year. In addition, the firms launched firm-wide training programs for all auditors on data science and how to use new solutions, as well as digital certificate programs linked with online training courses. Finally, the firms further developed new career paths for auditors and other non-auditor experts, to incorporate digital skills into auditors' required skill sets and enable non-auditor experts such as data scientists to achieve career development within the audit firms in the long term. A Partner at Firm A suggested the significant need for transforming auditors' skills, roles, and mindsets to adjust to the changes, behind these supports:

> "We auditors will continue to be the core of auditing, but future auditing will not be possible without non-auditor expertise in data or technology. In reality, we already rely on non-auditors in our shared service center. We centralize and delegate each task category to experts in each area…. Audit professionals will support the overall coordination. …So, naturally, auditors will involve those 'hybrid' people, who will be both auditors and data scientists."

4.3.3. Operating principles

The case firms maintained principles that prioritized flexibility of focus changes and autonomy of professionals in these activities. In this phase, they also focused on *incorporating a market mechanism* into their implementation activities. The benefit of this principle was that such arrangements would help screen the best solutions that practically would work for each service context. Specifically, the service R&D units in all firms allowed each audit team to determine which tools to use and to what extent. Although the service R&D units provided suggestions when requested, they refrained from excessive intervention. Furthermore, the service R&D units gradually allocated the costs of their new tool development and implementation support to frontline audit teams. In earlier phases, the cost of service R&D was a common cost for the firm's headquarters. In this implementation phase, the service R&D units set internal fees for audit teams that used extra support or new customized tool development. In addition, the AI and other solution tools were openly shared internally on the global intranet website of each audit group, which helped frontline auditors choose and test technological solutions that best fit individual contexts.[19] The frontline audit teams had three choices: (a) adopt existing tools from their domestic solution menu, (b) adopt existing tools from other member firms in the same group, or (c) get hands-on support of service R&D for adopting or customizing existing tools or developing new tools. The first two were generally free, but the third would generate internal fees. As the audit teams' choices accumulated, the popularity of each tool became clear. Based on the usage record, the service R&D units planned their new solution development and prioritized "best-seller" tools in their internal promotion of AI tools. Such selective tool adoption resonated well with the limitations of budgets, time, and resources that the frontline auditors faced daily. Although the auditors generally appreciated and welcomed the increasing use of new tools, they perceived the risk of naïve reliance on new tools and the significance of carefully selecting new tools. The intention here was that cost burdens would urge frontline audit teams to seriously consider returns on investment, leading to the selection and survival of the best innovations that were truly useful for practice. A Manager at Firm B explained this consideration—associated with the perception that available AI tools were not necessarily capable enough—behind the introduction of such market mechanisms:

> "Analytics tools inform us of tons of details about various companies. But the opportunity for those tools to help to audit directly is still limited. In the end, these tools cannot directly identify misstatements by client firms. So, theoretically, we think it's better to use them, but practically we should make a careful comparison between the cost and how much we really want to understand details."

Another operating principle unique to this phase was *situating the change in the big picture*. The professionals framed the organizational change and innovations as their resonance with the ongoing transformation in the broader society driven by digitalization. Specifically, all four firms launched their global group agendas of transforming auditing practices and creating new services toward more effective and productive ones using new technologies. With various names, such as "Assurance 4.0" at EY and "Audit transformation" at Deloitte, they promoted various internal activities globally. Leveraging the global agenda, the firms positioned service R&D activities as the core of their corporate planning and management functions. This shift was reflected in the service R&D's communications to frontline auditors on future visions of the audit profession and audit work. In particular, they stressed that the change was beyond the task level but involved the workstyle (e.g., collaboration with data scientists), skills, and career paths. By highlighting these fundamental changes, aligned with the broader societal changes, the firms legitimated AI adoption and related changes as highly relevant and urgent. A Partner at Firm D described their intention to stress the fundamental shift of the professionals' role in intra-firm communications:

> "There is no doubt that accountants will continue playing a central role, but […] without digital data or technology experts, we will not be able to audit. Where engineering, such as automation or analytics, is needed, data scientists will manage those tasks. Then we, the audit professionals, support them. Drawing and moving toward such a picture is what we call [the future of auditing]."

[18] This included the application of both AI tools and non-AI data analytics tools.

[19] In this respect, the Big Four firms in Japan were among those leading member firms in the Big Four groups that proactively invested in internal tool development and sometimes exported solutions. For instance, a team of the service R&D in EY ShinNihon was awarded by EY Global in 2018 for their software solution using machine learning algorithms to detect anomalies in a general ledger automatically.

5. Discussion

5.1. Service R&D in PSFs

This study examined the ways in which the Big Four audit firms in Japan successfully established, developed, and utilized service R&D in incorporating AI into their external audit services.

Specifically, the first phase focused on planning and preparation, beginning with a small core team that designed the structure of innovation initiatives, prioritizing flexibility as its operating principle. After the official launch of the initiatives, the second phase focused on ideation. The service R&D expanded to involve dozens of professionals, on a part-time basis, who engaged in researching innovation ideas, both inside and outside the audit firm, and conducted pilot testing with selected frontline projects. The firms highly respected the autonomy of professionals in seed search and pilot tests to maximize their range of exploration. Along with these activities, service R&D began to streamline professionals' tasks in preparation for future innovation adoption efforts among frontline professionals. In the third phase, which focused on codification, service R&D further expanded to involve more than a hundred frontline professionals as innovation facilitators and was upgraded to one of the core functions of firm management. While ideation activities continued, the focus shifted to installing and adjusting innovations in the frontline audit teams, with initiatives to diffuse new solutions and support professionals. As its operating principles, service R&D incorporated a market mechanism for selecting innovations best suited for service needs and situated the change within the bigger picture of societal transformation through technology to establish the legitimacy of the innovations.

In more detail, the present study provides two additional insights into how PSFs can establish and utilize service R&D to innovate their existing services. First, the innovation process by the service R&D units supported two basic principles suggested by the existing literature. The first is the emphasis on experimentation, which has long been stressed in innovation studies (West and Iansiti, 2003). Throughout the observation period, the service R&D units presupposed some failures in their tool development and rejections of frontline tool adoption. The case firms shared a perception that such trials and errors were necessary for identifying what would practically work from a wide range of technological seeds, because it was almost impossible to predetermine the best solutions in auditing—a professional service highly customized to each client.

The second was the prioritization of digitalization as a key strategic agenda at the firm management level. Information systems research has suggested that information technology today has become closely linked to firm strategic alignment and performance, which are two central agendas in firm management (Gerow et al., 2014; Wu et al., 2015). Aligning with theory, all case firms showed their firm-level strong commitment to AI adoption, particularly toward the end of the observation period. The commitment of leaders, the introduction of certain catalysts for change, and careful management of firm culture have been pointed out as key success factors by practitioners in diffusing digital innovations to highly autonomous professionals (Dodgson et al., 2022). This study substantiates the significance of those change management factors in service R&D.

Second, the present study implies that service innovations in PSFs can be influenced by their global network if the focal firms are involved in multinational operations. Although the case firms autonomously initiated and managed their innovations as independent legal entities, the Big Four global group organizations also indirectly contributed to the local innovation processes.

Specifically, the headquarters and their regional sections of the Big Four groups facilitated exchanges among the member firms regarding information about technological seeds, use cases, vendors, and available tools developed within their networks. The data suggest that the group organizations provided such a function by (a) websites on their intranets for knowledge and tool exchange, (b) formal periodical meetings as communication opportunities among member firms, and (c) ad-hoc global interactions among individual auditors. With these, the global group functioned as one of the significant sources of information, technological seeds, and solution tools. Fig. 4 summarizes this relationship between a global group and its member firms.

Importantly, this structure is partially similar to that of R&D in multinational corporations, frequently studied in manufacturing. Studies on R&D in multinational corporations have highlighted the tension between the headquarters prioritizing control and subsidiaries pursuing autonomy (Asakawa, 2001; Collinson and Wang, 2012). Meanwhile, in the context of the present study, membership relationships by contracts without financial ownership set a peculiar structure that allowed for substantial autonomy for member firms. Although the present study has focused on the firm-level process and left the group-level initiatives out of the main focus, the findings imply that global service organizations, such as the group headquarters of the Big Four, might have their own interests in central coordination and face challenges in balancing autonomy and control, as firms in the manufacturing sector do.

5.2. Contributions

This study contributes to expanding knowledge of innovation in services and PSFs in three ways. First, the findings demonstrate the value of service R&D as a neglected but critical enabler of innovation in PSFs, particularly when these firms need to incorporate new knowledge outside their existing expertise. Past studies have stressed ad hoc innovations (Gadrey and Gallouj, 1998; Gallouj, 2002)—distributed innovations by individual frontline professionals—and the way firms can prepare an environment suitable for these improvisational efforts in terms of organizational structure (Anand et al., 2007), knowledge management system (Fu, 2015), multifunctional working, and external relationships (Bourke et al., 2020). Though the concept of service R&D has long been proposed, it has attracted little scholarly attention, with only a few reports on empirical cases (Miles, 2007), leaving the potential value of expertise-field and anticipatory innovations unexplored (Gallouj, 2002). To address the need for exploring the role of service R&D (Doloreux et al., 2016; Miles, 2007), this study reveals that the management of PSFs can engage in innovations more directly by investing in and setting up a dedicated organizational function to enable the acquisition of new knowledge in target areas. Thus, this study suggests that service R&D can be one approach to resolve the paradox of the value of central coordination versus the values of individual autonomy for innovations in PSFs.

Second, by explicating the detailed process, this study constructs a model of how innovations enabled by service R&D can unfold in PSFs. Notably, the model reveals two aspects of the true nature of service R&D in PSFs. The first is that the function of service R&D does not focus only on centralized research and decision-making. Instead, innovations enabled by service R&D involve a mix of top-down and bottom-up activities. Early studies speculated that service R&D might play a role distinct from manufacturing R&D in the coordination and diffusion of innovations (Dougherty, 2004; Rubalcaba et al., 2012). This study fleshes out how central control and delegated improvisations can intertwine and complement each other through facilitations by service R&D. In other words, the study suggests that the significance of service R&D lies in its role as an enabler and facilitator of the balance between control and delegation, besides its capacity to research and acquire new knowledge.

The second feature of service R&D that this study locates is its dynamic nature. The proposed model suggests that the organizational structure, innovation activities, and operating principles of service R&D are not fixed; they evolve continuously. Past studies on innovations in PSFs have focused on the content and effectiveness of specific innovation practices and firm features, such as organizational structure,

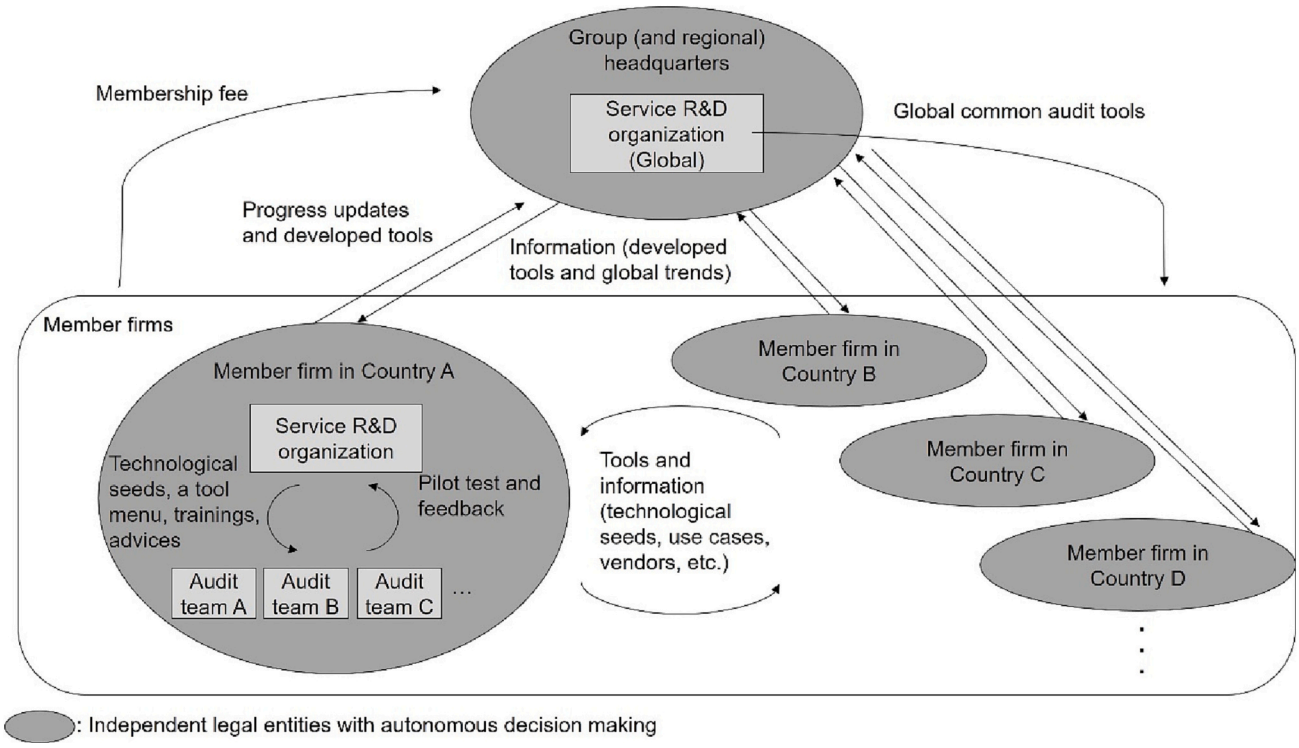

Fig. 4. Structure of innovation activities of the Big Four firms.

multifunctional teams, teamwork, collaboration with different stakeholders, and innovative culture (e.g., Anand et al., 2007; Bourke et al., 2020; Villani et al., 2021). By showing a drastic shift in service R&D's innovation activities and operating principles over phases, this study implies that a key function of service R&D lies in its ability to combine and shift its set of practices adjusting to the maturation of innovations, rather than in individual practices themselves. Namely, one crucial role of service R&D is managing changes regarding what innovation initiatives are required within what timeline.

Third, this study expands our knowledge of approaches for legitimating innovations in PSFs. In managing innovations in PSFs, a crucial challenge is establishing the legitimacy of new practices (Anand et al., 2007; Barrett and Hinings, 2015; Gardner et al., 2008). Prior research has highlighted legitimation strategies at the rhetoric and negotiation tactics level, such as extending existing frameworks, claiming relevance to client needs, and persuading internal power holders (Anand et al., 2007). This study illustrates that PSFs can address this challenge using two approaches facilitated by service R&D: the engagement of frontline professionals in core innovation processes and the contextualization of firm-wide innovations in digital transformation as societal change. Direct involvement can encourage professionals to support innovations because these innovations will reflect their own knowledge and opinions (Katz and Allen, 1982). Also, as digital transformation became an essential agenda for society (Goto, 2021), situating technological innovations in this larger context could help legitimize them. Indeed, the findings show that these approaches played an important role in the codification of innovations, corroborated by significant investments in all-member training and new career path designs as evidence of the firms' commitment to change. Thus, this study suggests that the legitimation of innovations in PSFs can be linked with and enhanced by the design of the innovation process itself, beyond rhetoric and negotiation tactics that can be separate additions to the innovation activities.

In addition, this study contributes to the emerging literature on AI adoption, particularly for professional services, by demonstrating the understudied process of AI adoption and elucidating how PSFs can address the challenges peculiar to AI adoption. Specifically, the findings show that the case firms started their innovation activities with small groups of interested people and then gradually expanded and formalized the activities but loosely controlled them to maintain flexibility. This process design, which enabled gradual investments and flexible changes, could effectively address the high uncertainty surrounding professional services and AI (Goto, 2022). Furthermore, the case firms' intensive use of pilot tests starting in the second phase could address the obscurity of AI capacity in specific professional task contexts (Pakarinen and Huising, 2023). Through pilot tests, the case firms could accumulate knowledge of what worked in practice without excessive commitments to particular solutions. In addition, intra-firm communications stressing auditors' role changes starting in the third phase resonated with the need for identity change and cultural transformation in AI adoption for professional services (Goto, 2021). With these findings, this study suggests the significance of an innovation process tailored to the nature of the technology and focal context, and exemplifies such a process—the phased, experiment-driven, and inclusive innovation process enabled by service R&D—for AI adoption in professional services.

5.3. *Limitations and future research*

The current study has a limitation in that the case context sets specific contextual factors, and the findings should be interpreted considering those conditions. Specifically, three factors should be considered in interpreting the generalizability of this study's results: the country (where), the type of PSFs (who), and the subject of innovation (what).

First, the country context (Japan) could have affected the availability of external solution vendors. The current case context allowed easy access to multinational IT firms, AI start-ups, and university researchers. The profession's maturity in the country was also important because that created the peculiar challenge of incorporating new technologies into autonomous professionals' established practices. Thus, the current findings could have more relevance to developed countries. As a side note, though the impact on the structure of the innovation process was limited, the country-specific factors of low ERP penetration and language barriers could have increased the number of customized solutions.

Second, the type of PSFs (the Big Four audit firms) could have affected the nature of the knowledge they had, firm size, and the availability of global networks. One crucial precondition of the current case was that technology was outside the PSFs' expertise. Thus, the process could be highly different in technology-based knowledge-intensive business service firms (t-KIBS) with technological expertise. Among professional knowledge-intensive business service firms (p-KIBS), such as law firms, patent offices, and consulting firms, the current findings are likely applicable because the methods of technology application observed were not necessarily specific to auditing (e.g., contract verification and profit forecast). In addition, the large firm size enabled the case firms' internal tool development, and the global networks provided them with more information and solution tools. In smaller PSFs with more limited access to global networks, service R&D initiatives could be more reactive and small-scale and rely more heavily on external vendors (de Jong and Marsili, 2006; e.g., Cardinali et al., 2023). Thus, the findings likely apply to large PSFs (p-KIBS) with international networks or operations.

Third, the subject of innovation (AI for existing auditing services) could have affected the path of innovation. It has been reported that PSFs can adopt innovation strategies different from this study's findings when diversifying their services, such as allocating resources for individual professionals' entrepreneurial market creation (Anand et al., 2007) and establishing a sector-wide institution (Gendron and Barrett, 2004). The nature of the focal technology—an influential technology that could affect a wide range of professional tasks—was also essential because other technologies with fewer impacts or a narrower focus could be handled within daily operations or smaller task-force teams. Thus, the findings likely apply to innovations incorporating new influential technology for various uses into existing services.

The present study implies three important areas for future research. The first is the study on service R&D at the global level. As explained, this study focused on the country level. Although the Big Four member firms are the key innovation actors in their group structure, understanding the service R&D from their global headquarters' perspective will benefit our knowledge. The second is the possible variations in service R&D and its processes. Future research can explore these potential variations in service R&D processes for service firms based on the abovementioned criteria. The third area for future study is longitudinal change. The current study only explored the early stages of innovation enabled by service R&D. As technology continues to advance, just as we observe the rapid growth of generative AI, the service R&D function will retain its critical position in the firm, and many more innovative solutions are liable to be developed, calling for even more attention to skills, retraining, and support for professionals learning to choose and use these systems. Thus, longitudinal studies can be fruitful in revealing the potential for the further evolution of service innovation in the age of digitalization.

CRediT authorship contribution statement

Masashi Goto: Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Funding acquisition.

Declaration of competing interest

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

Data availability

The authors do not have permission to share data.

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