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Opportunities and challenges in the new innovation landscape: Implications for innovation auditing and innovation management

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ABSTRACT

Innovation auditing is a well-established practice used by managers to identify strengths and weaknesses in innovation. Existing audit frameworks fall short, however, because they neglect three major trends that currently transform the innovation landscape. These trends are as follows: 1) a shift from closed to more open models of innovation ("openness"), 2) a shift from providing physical products to industrial product–services ("servitization"), and 3) a shift from an analog to a highly digitalized world ("digitalization"). This article identifies new innovation practices, opportunities, and challenges that arise for manufacturing firms along these trends. The article proposes a revised innovation audit framework, which acknowledges these trends and supports innovation management in increasingly dynamic and competitive environments.

1. Introduction

An innovation audit is an analytical framework that allows benchmarking of a firm's current innovativeness to past or desired performance levels (Burgelman, Christensen, & Wheelwright, 2009). Innovation auditing has been a subject of both empirical and theoretical research (e.g. Björkdahl & Holmén, 2016; Chiesa, Coughlan, & Voss, 1996; Cormican & O'Sullivan, 2004; Radnor & Noke, 2002). Furthermore, frameworks for innovation auditing are part of the standard repertoire in innovation management textbooks (e.g., Goffin & Mitchell, 2016) and many leading management consultants now have their own versions. A.T. Kearney's *Kearney House of Innovation* and McKinsey's *7-S Framework* are well-known examples. By auditing a firm's current innovativeness, the stage is set for better and more innovative products and services and/or other types of innovations that a firm may focus at (Sawhney, Walcott and Arroniz, 2006).

Yet, existing auditing frameworks fail to account for recent transformations in how innovation is being pursued by firms. This transformation is driven by three trends: toward more open innovation; toward increased servitization; and toward a more digitalized world. Combined, these trends change innovation from being an inward-focused, product-centric, and largely analog activity to an outward-focused, service-oriented, and highly digitalized one, cutting across internal functions and involving customers, suppliers, and even competitors (Brynjolfsson & McAfee, 2014; Dahlander & Gann, 2010; Parida, Rönnberg Sjödin, Wincent, & Kohtamäki, 2014).

From a theoretical perspective, the three trends are important because they introduce a new set of mechanisms and contingencies that are critical for understanding innovation in manufacturing firms. For instance, consider open innovation practices that bring novel cognitive challenges to managers, who now need to sort and make sense among a larger and more diverse set of issues (Cassiman & Valentini, 2015). Such cognitive implications for

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decision-making are yet to be considered in innovation audit research.

In a similar vein, much of extant auditing literature is based on the idea of knowledge concealing, where uniqueness is seen as a firm-level core competitive advantage (Hallberg & Brattström, in press). However, as innovation becomes more open, servitized, and digitalized, previously concealed knowledge might now benefit from being revealed to other actors in the ecosystem (Alexy, George, & Salter, 2013). Thus, the complexity of the business model increases as previously distant actors are involved, and new values can be offered in ways that are completely new for the manufacturing firm (see e.g., Porter & Heppelmann, 2014).

The lack of attention to openness, servitization, and digitalization in previous frameworks is problematic. Because extant frameworks fail to address these trends, managers who use them risk ending up in either of two unfavorable outcomes. They either fail to adapt when openness, servitization, and digitalization transform the innovation landscape because current innovation auditing frameworks make them miss these trends or rush ahead to adapt very quickly, but lack sound recommendations for how to address them.

Hence, the purpose of our paper is to provide an updated innovation audit framework. Our framework addresses the opportunities and challenges that stem from increased openness, servitization, and digitalization and entails critical questions managers may ask when auditing innovation in a rapidly changing innovation landscape. As our core contribution, we provide actionable advice, thus helping managers to make informed responses regarding open innovation, servitization, and digitalization.

To do this, we build on insights from prior literature (e.g. Chiesa et al., 1996; Cormican & O'Sullivan, 2004; Radnor & Noke, 2002) combined with data from a three-year research project on innovation auditing and innovation measurement. Based on our findings, we address how openness, servitization, and digitalization transform core dimensions of innovation management and auditing in manufacturing firms: the innovation process; the innovation culture; the innovation resources and capabilities; and the business model. Subsequently, we discuss both opportunities and challenges that arise under such transformations. Finally, we present an updated innovation auditing framework which encompasses critical questions managers need to ask when auditing innovation in a changed innovation landscape.

2. Innovation auditing in extant theory and practice

Innovation audits enable managers to identify strengths and weaknesses in innovation.[1] By extension, an innovation audit allows firms to create and sustain competitive advantage by building innovative capabilities (Björkdahl & Holmén, 2016). An innovation audit is future oriented and goes beyond pure quantitative measurement. It combines quantitative data with qualitative insights, focuses on gaps between current and desired performance, and allows managers to develop action plans (Chiesa et al., 1996). The majority of extant frameworks originate in technological innovation or new product development (Hallgren, 2009). Recent audit frameworks, however, acknowledge that innovation encompasses more than merely developing new physical products (Rao & Weintraub, 2013; Richtnér, Brattström, Frishammar, Björk & Magnusson, 2017).

Four key dimensions or audit elements reoccur in most prior frameworks, and we focus our analysis on these dimensions (see Fig. 1).

At the center is the *innovation process*. This process consists of ideation, development, and launch activities (packaged into a stage-gate process or equivalent) with some 5–7 overlapping stages and predefined gates for evaluating progress (Cooper, 2008). Supporting the innovation process, most innovation audits acknowledge structures in the form of *innovation resources and capabilities*, *innovation culture*, and *business model* (although these are sometimes labeled using different terms).[2] *Resources and capabilities* fall into two dimensions: human and financial resources (mainly used for internal development) and capabilities in ideation, technology acquisition, etc.; they are defined as assets controlled by a firm that enable it to implement strategies to enhance efficiency and effectiveness (Barney, 1991). *Innovation culture* emphasizes the values, norms, and beliefs that encourage proactivity, risk taking, commitment, and change (Rao & Weintraub, 2013). Finally, we think of a *business model* as a cognitive schema that explicates how a company creates, delivers, and captures value through the exploitation of business opportunities (Massa, Tucci, & Afuah, 2017).

Table 1 provides representative examples of innovation auditing frameworks from three sources: academic journals, textbooks, and consultancy companies.

In *academic literature,* the seminal work by Chiesa et al. (1996) represents an early and important contribution. These authors identified four core processes to audit: 1) concept generation, 2) product development, 3) process innovation, and 4) technology acquisition. These are supported by three enabling processes: 1) human and financial resources, 2) systems and tools, and 3) senior management leadership. The focus is on whether suitable processes and practices are in place, along with the outcome of those processes and practices. Similar conceptualizations can be found in the works by Radnor and Noke (2002) and Cormican and O'Sullivan (2004). Across these frameworks, innovation and new product development performance is the outcome variable. A different approach is proposed by Björkdahl and Holmén (2016). Rather than starting with predefined audit dimensions, they advise firms to search for valuable innovation problems. By passing through contextualization, problem identification, problem assessment, and problem evaluation and analysis, a firm's main innovation problems can be identified, and innovation processes and capabilities can be improved.

Nearly all *technology and innovation management textbooks* include sections on innovation auditing. For example, Burgelman et al. (2009) proposed a framework consisting of resource availability, technological environment, strategic management capacity, structural and cultural context, and competitors' strategies and

[1] Innovation audit is the most widespread term—but not the only one used—for assessing strengths and weaknesses in innovation. Approximate synonyms include innovation assessment tool, innovation performance indicator, innovation maturity assessment, innovation evaluation, and innovation assessment.

[2] We do acknowledge that additional audit dimensions may be relevant. These include innovation in manufacturing processes (Chiesa et al., 1996, op. cit.), leadership and team composition (Radnor & Noke, 2002, op. cit.), scanning of the external environment (Burgelman et al., 2009, op. cit.), and portfolio management. However, for reasons of parsimony, we focus our analysis on the key core and enabling processes and outcomes. Moreover, older audit frameworks such as the ones proposed by Cormican and O'Sullivan (2004) and Burgelman et al. (2009) used the term "innovation strategy" rather than "business model," which has become the dominant term in more recent literature. To avoid confusion and mix-up of terms and concepts, we use the term "business model" throughout this paper. Finally, much of the business model literature treats resources and capabilities as an integrated part of the business model. However, we view resources and capabilities as a separate dimension in our analysis, which is consistent with how resource-based literature sees the link between resources and strategy (Barney, 1991). This choice is also consistent with the innovation audit literature at large.

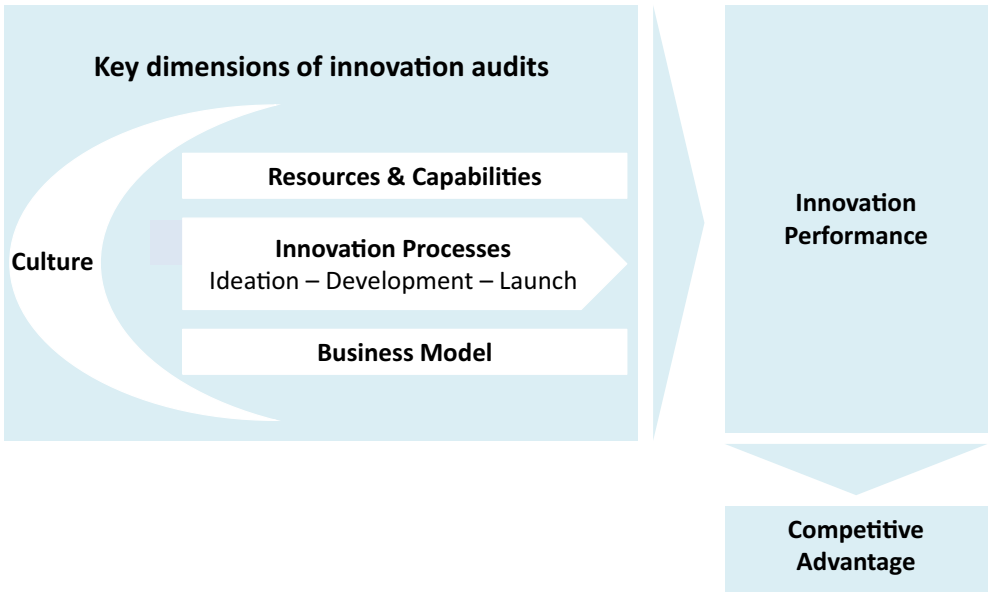

Fig. 1. Key dimensions of prior innovation audit frameworks.

industry evolution (Burgelman et al., 2009). Cetindamar, Phaal, and Probert (2010) also focused on resources in technology and innovation, although their framework provides fewer details. Goffin and Mitchell (2016) suggested that innovation auditing should focus on the innovation process—from idea generation to implementation—supported by three core themes: 1) innovation strategy, 2) people, and 3) organization.

In addition, there are multiple *consultancy examples of innovation auditing frameworks.* These range across global consultancy firms, which all have their own tweak, such as A.T. Kearney's "Kearney House of Innovation" (A.T. Kearney, 2017), or the McKinsey 7-S Framework. Another example is the Product Development Institute with their "Innovation Performance Framework". Two other examples are InnovationLabs that developed the "Innovation Master Plan" (InnovationLabs, 2017) and the Innovation Excellence model created by Innovate! (Innovate!, 2017). In addition, there are many government-sponsored initiatives and organizations that also propose their versions of innovation audits.

To sum up, the proliferation of audit frameworks reflects the importance of innovation auditing for innovation management in firms. However, most current audit frameworks appear to be inward focused and largely fail to acknowledge the open and distributed logic that characterizes innovation at present. Although some models (e.g., Chiesa et al., 1996) acknowledge the importance of networks and external collaboration, they overlook the more fundamental implications brought about by the open innovation literature. The transition from product development to industrial product–services is also downplayed despite its critical importance to many manufacturing companies. Some frameworks touch upon this trend (e.g., Rao & Weintraub, 2013), but it is not at the core of any existing audit framework, and its wide reaching implications are not thoroughly elaborated. Finally, the recent influence of digital technologies on innovation is not elaborated in any audit framework reviewed nor are the implications that these technologies bring about. These problems are clearly illuminated at the right side of Table 1. In short, given the profound impact of openness, servitization, and digitalization on innovation management, there is a need for updating current frameworks. The next section presents our methods for updating frameworks.

3. Methods

Our research process unfolded over three years within the scope of a broader research project on innovation auditing and measurement. Given our objective to create actionable advice, and the lack of prior research on the effect of openness, servitization, and digitalization on innovation auditing, we followed a collaborative research approach based on close collaboration with selected companies (Shani & Pasmore, 1985). The collaborative approach is appropriate for unstructured and integrative issues, of which innovation measurement and auditing are good examples. By deliberately involving companies in the learning process, we created in-depth insights into the practical usability and relevance of our analysis (Coughlan & Coghlan, 2016). Our data encompass the following: 1) qualitative and open-ended survey responses from a broad number of firms; 2) interviews from experts on innovation management and measurement; 3) in-depth case studies in three case companies; and 4) feedback from practitioner workshops, where emergent results were presented.

3.1. Open-ended survey to 45 managers in 21 different firms

In April 2014, we distributed a qualitative survey to 45 managers working with innovation management in 21 different Swedish firms. Our sample included a variety of different manufacturing firms as well as consultancy firms specializing in strategy and innovation management. The purpose of the survey was to provide insights into what practical challenges managers face when measuring and auditing innovation. Similar to an open-ended interview protocol, we stated broad questions and asked respondents to provide written, essay-like responses. Questions concerned, for example, how the firms currently worked with innovation, what they considered to be future trends, and what challenges they faced when auditing and measuring innovation. The survey generated a broad understanding of innovation auditing problems. It also illustrated the relevance of openness, servitization, and digitalization as three broad trends with implications for auditing.

Table 1
Examples of prior academic and practice-oriented literature on innovation auditing.

Authors and year	Publication by	Key audit dimensions	Outcome variables	Comments, including limitations	Extent to which openness, servitization, and digitalization is addressed
Björkdahl and Holmén (2016)	Case study, R&D Management	Innovation processes and innovation capabilities	An innovation "Problem", i.e. some specific negative consequence or deficiency a firm should address	• The focus is on finding and formulating innovation-related problems. • The drawback of the emphasis on the "problem" is that little guidance is provided to managers on how to assess their innovation performance.	As the emphasis is on identifying firm-specific "problems" the audit does not address openess, servitization, or digitalization explicitly
Chiesa et al. (1996)	Case study, Journal of Product Innovation Management	Concept generation, product development, process innovation, technology acquisition, human & financial resources, systems and tools, and senior management leadership	Innovation performance and competitiveness	• A thorough and early attempt at defining innovation audits, making it an all encompassing framework. • Focuses on technical innovation auditing, i.e. more recent innovation trends are not included in their innovation audit framework.	No comments on openness, servitization, or digitalization.
Radnor and Noke (2002)	Case study, Creativity and Innovation Management	Structure, leadership, output, teams, and context	New product performance	• Uses an "innovation compass" to distinguish between current and desired innovation performance. • Used qualitative and quantitative data as basis for the development of the model [innovation "compass"].	No comments on openness, servitization, or digitalization.
Cormican and O'Sullivan (2004)	Case study, Technovation	Strategy and leadership, Culture and climate, Planning and selection, Structure and performance, and Communication and collaboration	New product performance	• Identifies a best-practice and score card model based on qualitative case studies. • Do not discuss degree of innovation, nor the nature of innovative ideas.	No comments on openness, servitization, or digitalization.
Rao and Weintraub (2013)	Case study, MIT Sloan Management Review	Resources, Processes, Success, Values, Behavior, and Climate	Innovation performance and competitiveness	• Offers a model of the key elements to build an innovative culture. • Exemplifies a practical 360-degree assessment tool. • Emphasis is primarily on assessing the innovation culture.	Touches upon the themes of openess and servitization, but no comment on digitalization.
Burgelman et al. (2009)	Textbook	Resource availability, Technological environment, Strategic management capacity, Structural and cultural context, and Competitors strategies and industry evolution	Assessment of business unit or corporate innovation strategy	• A general model for auditing innovation is offered. • Is primarily taking an overall strategic perspective, excluding different types of innovation.	No comments on openness, servitization, or digitalization.
Cetindamar et al. (2010)	Textbook	Technological resources and capabilities	"Status" of technologies	• The emphasis is on technology and the associated resources and capabilities. • Do not discuss degrees or types of innovation.	No comments on openness, servitization, or digitalization.
Goffin and Mitchell (2016)	Textbook	Innovation process (from ideas to implementation), Innovation strategy, and People and organization	Innovation (broadly defined)	• Makes a broad assessment of innovation – both the process and the supporting structures.	Touches upon the themes of openess and servitization, but no comment on digitalization.

Table 1 (*continued*)

Authors and year	Publication by	Key audit dimensions	Outcome variables	Comments, including limitations	Extent to which openness, servitization, and digitalization is addressed
				• Includes a limited discussion on the degrees and types of innovation.	
Dodgeson, Gann, and Salter (2008)	Textbook	Resources for innovation, Innovative capabilities, and Innovation processes	Innovation (broadly defined)	• Takes a broad view on innovation and presents a model for innovation assessment. • The model does not comment on the degrees of innovation.	No comments on openness, servitization, or digitalization.
Kearney House of Innovation	ATKearney	Innovation strategy, Organization, Culture, Innovation life cycle process, and Enabling factors	Innovation outcomes	• Emphasis is on a broad understanding of innovation, inter-linkages between the parts, but also on high-lighting "growth" champions. • Do not discuss degrees of innovation, nor nature of ideas.	No comments on openness, servitization, or digitalization.
The Innovation Performance Framework	Product Development Institute	Product innovation and technology strategy, Portfolio management, Idea-to-launch process, and Culture and leadership	Innovation performance	• Makes an explicit emphasis on product innovation. • Not entirely clear on the importance and implications from degrees and types of innovation.	No comments on openness, servitization, or digitalization.
The Innovation Audit	InnovationLabs	Innovation strategy, portfolio, processes, culture, and infrastructure	Innovation performance	• Examines 7 technical and 7 cultural factors respectively that are critical to innovation performance and help shape innovation capacity. • Is performed by external experts, so difficult to make a self-assessment.	No comments on openness, servitization, or digitalization, but these may come up in the assessment.
Innovate!	Platform for innovation management	Innovation process (from front-end to launch) and innovation system (with the components of culture, strategy, organization & resources)	Innovation performance	• Examines different key components which a firm may want to audit.	No comments on openness, servitization, or digitalization.

3.2. Expert interviews

In December 2014, we conducted interviews within an expert consultancy firm that specializes in innovation management and measurement. We interviewed three senior members of this firm, following an open-ended interview protocol. The interviews resulted in a rich empirical account of critical issues associated with the measurement and auditing of innovation. Similar to the pattern we identified in the survey responses, the relevance of openness, servitization, and digitalization was prevalent also in these interviews.

3.3. In-depth case studies in three manufacturing firms

Between December 2013 and December 2015, we engaged in a multiple case study of innovation measurement and auditing practices in three large companies. Our first case company is Consumer Goods, a multinational consumer goods company, known for its continuous development of innovative consumer products. We conducted eight interviews within Consumer Goods, lasting between 30 and 60 min. Our second case company is Mining, one of Europe's largest iron ore producers. At Mining, we conducted nine individual interviews, lasting between 30 and 90 min. In addition, we conducted a workshop with nine managers from Mining's R&D unit. Our third case company is Machine Products, a multinational developer and manufacturer of automotive vehicles. At Machine Products, we conducted six interviews with middle- and senior-level managers, all working with innovation and product development. All company names are pseudonyms.

In total, we made 23 interviews in these three companies and we interacted with additional 7 informants through the group workshop. All interviewees were middle- or senior-level managers, or senior engineers, who were actively involved in innovation measurement and auditing. Examples include R&D managers, innovation managers, IP managers, and product development project leaders. To complement the interviews, we were granted access to internal documents such as power point presentations and internal reports.

The majority of interviews were conducted after the collection of survey responses, which allowed a more focused data collection based on the issues identified in the survey. Interviews followed an open-ended protocol, thus focusing on two major themes. First, we sought to identify current innovation measurement and audit practices in the case companies. Second, we discussed openness,

servitization, and digitalization (identified as important trends in the larger sample of firms) and asked managers to reflect upon how these trends transformed innovation management in general, and measurement and auditing in particular. To avoid impression management, we asked informants to provide context-specific examples from their firms with regard to the three trends.

After conducting interviews, we started to compare and contrast information from the three cases, thus seeking to identify themes that consistently emerged across the cases. For example, we analyzed the opportunities and challenges that our informants identified in association with the three trends (see Table 3). Based on these insights and the review of previous literature, we developed a first draft of our paper.

After we had a first version of the analysis at hand, we conducted two feedback sessions with key informants from our case companies. We also conducted one feedback interview with a representative from the expert consultancy firm that we initially interviewed. In these sessions, we presented emergent findings and asked informants to reflect on them. These feedback sessions were valuable not only to confirm our interpretation of data but also to gain deeper insights into opportunities, challenges, and emergent versions of the innovation audit framework.

3.4. Feedback from practitioner workshops

Fourth and finally, we collaborated with the Association for Innovation Management Professionals in Sweden to further refine the emergent framework. Specifically, we conducted workshops with 19 R&D managers, innovation managers, IP managers, and project leaders working with innovation measurement and auditing in different industries. In these workshops, we presented the emergent framework and asked for feedback regarding usefulness, general applicability, and potential missing factors. Based on this feedback, we made additional edits and fine-tuning.

4. Three trends that transform innovation auditing practices

Among manufacturing firms, innovation management is undergoing a major transformation. It is changing from being an inward-focused, product-centric, and largely analog activity conducted by R&D — to an outward-focused, service-oriented, and highly digitalized activity, cutting across internal functions and involving customers, suppliers, and even competitors. Three trends are driving this transformation.

First, the locus of innovation is changing, from being closed to being increasingly open (Chesbrough & Brunswicker, 2014; Dahlander & Gann, 2010). This means that firms purposely seek to increase both the inflow and outflow of innovation-related knowledge to improve their innovation capabilities, as well as increase their markets for innovation (Chesbrough, 2006).

Second, value propositions of manufacturing firms are transforming, from being based on development and manufacturing of physical products to providing integrated product–service offerings (Baines, Lightfoot, Benedettini, & Kay, 2009; Parida et al., 2014). Following this "servitization" trend, many manufacturing firms are repositioning themselves as solution providers and exploring new ways to generate and capture value.

Third, products and services are increasingly being digitalized (Brynjolfsson & McAfee, 2014; Iansiti & Lakhani, 2014). That is, they combine physical components (i.e., traditional hardware) with smart components (e.g., sensors, microprocessors, and software) and connectivity (e.g., ports, antennas, and wireless protocols) (Porter & Heppelmann, 2014). Such digitalization offers imply endless opportunities for new functionality, utilization, and capabilities.

Manufacturing firms are recognizing the impact of openness, servitization, and digitalization on their business in general, and on innovation in particular. *Openness* has received enormous attention, thereby leading the Financial Times to declare it as a growing global trend among big companies. Advanced *services* now provide the lion's share of profit in global manufacturing firms such as Ericsson and Metso. *Digitalization* is expected to deliver annual growth and cost efficiency improvements of 5% to 10% in the next three to five years, according to the consultancy firm McKinsey (Tanguy, Scanlan, & Willmott, 2015). In the present paper, we provide advice that helps manufacturing firms cope with these trends in a proactive and structured manner. We focus our analysis on innovation auditing because coping with these trends implies fundamental changes in how manufacturing firms audit and subsequently manage innovation.

In the following, we discuss the implications of these trends for the four dimensions of innovation management that are commonly subject to auditing: the innovation process; resources and capabilities; innovation culture; and the business model. Table 2 provides an overview of our analysis.

4.1. Trend #1: A shift from closed to open modes of innovation

Open innovation refers to "…a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization's business model" (Chesbrough & Bogers, 2014). Openness implies a major change with implications for all elements of innovation auditing.[3]

Innovation processes. An open and distributed process is fundamentally different from a traditional and closed one. Instead of relying on internal resources to identify, develop, and commercialize ideas, the open process focuses on connecting, mending, and developing *both* internal *and* external ideas, technologies, and products.

Openness applies to all phases of the innovation process (Guinan, Gourdreau, & Lakhani, 2013). In the front-end, openness can apply both to generating ideas and to selecting ideas. Ideas, concepts, and technologies can be spun-in and spun-out in collaboration with external actors. These may include individual inventors, start-ups, customers, or even competitors and provide complementary (or substitute) arenas for generating and developing ideas. Practical examples range from innovation tournaments, supplier collaborations, and R&D consortia (King & Lakhani, 2013). For manufacturing firms, these activities often aim to increase value in terms of accessing and utilizing knowledge, information, and creativity from sources beyond their own organization (Grönlund, Rönnberg-Sjödin, & Frishammar, 2010).

The idea of openness also applies to later stages of the innovation process. In design and development, internal technical problems can be solved through spin-in of external inventions by collaborating with innovation intermediaries, research institutions, suppliers, or others (Grönlund et al., 2010).

[3] As multiple authors have pointed out, open innovation is not new. Even the traditional or so-called "closed" models of innovation were open in the front-end phases, thus emphasizing inbound activities such as customer and supplier involvement (Florén, F., and J. Frishammar, "From Preliminary Ideas to Corroborated Product Definitions," *California Management Review,* 54/4 (Summer 2012): 20–43). Similarly, some 30 years ago, many authors noted a more open approach to innovation among industrial companies, which were increasingly acquiring external technologies for their portfolios (Spithoven et al., 2010, op. cit.). Some 100 years ago, many of the elements of the open innovation approach to R&D management were visible (Mowery, D.C., "Plus ca Change: Industrial R&D in the Third Industrial Revolution," *Industrial and Corporate Change*, 18/1: 1–50).

Table 2
Existing innovation audit elements in light of key innovation trends.

Audit Dimension	Traditional view	Openness	Servitization	Digitalization
Innovation process (Ideation –Development –Launch)	• Stage-gate process (Often 5–7 overlapping stages and predefined gates for evaluating progress)	• New inbound activities (spin-in ideas, concepts, and technology) • New outbound activities (Spin-out ideas, concepts, and technology) • Evaluation of open innovation potential of project at gates • Innovation tournaments and contests to improve idea generation and selection • Use of innovation intermediaries	• Integrate product development and service development • Early integration of customer input • Joint sphere for value co-creation	• Innovation eco-system perspective of innovation process • Crowd-sourcing (as alternative to in-house production or designated suppliers) • Use of agile development approaches for speed and flexibility • Software innovation through continuous upgrading and improvement
Resources & Capabilities	• Human and financial resources, mainly for internal development • Capabilities in ideation, technology acquisition, etc	• Develop absorptive capacity (for inbound open innovation) • Develop desorptive capacity (for outbound open innovation)	• Develop value co-creation capability • Develop network capability	• Develop ICT capabilities • Develop recombinative capabilities
Innovation culture	• Values, norms, and beliefs that encourage proactivity, risk-taking, commitment, and change	• Mitigate not-invented-here syndrome • Mitigate not-sold-here syndrome	• Build customer-centric culture	• Encourage improvisational and experimental elements of culture
Business model	• Integrated business model	• Open business model	• Use-oriented or result-oriented business models	• Traditional ownership or result-oriented business model
Innovation performance	• New product development performance	• New product development performance and additional revenues from licensing, sales, spin-off of technology	• Total performance of industrial product-services	• Total performance of industrial product-services

An open innovation process also has design implications for both stages and gates. For example, project evaluations at gate meetings must be conducted not only for internal usability but also for external potential (Cooper, 2008). Another example is using intermediaries that may perform a linking role and also help transform ideas and knowledge before transfer. For example, InnoCentive executes hundreds of such transactions every year (Terwiesch & Xu, 2008).

Resources and capabilities. When innovation opens up, managing knowledge and information across organizational boundaries becomes more important (Chesbrough, 2006). To manage inbound open innovation, that is, to use external knowledge in internal innovation, firms need absorptive capacity (Spithoven, Clarysse, & Knockaert, 2010). This includes the ability to acquire external knowledge from the environment, assimilate it into the firm's knowledge base, and apply it commercially (Lane, Koka, & Pathak, 2006). To manage outbound open innovation/outward knowledge transfer, firms need desorptive capacity. That is, the ability to identify technology transfer opportunities and to transfer technology to recipients (Fosfuri, 2006).

Innovation culture. To adopt an open innovation logic, two norms/values rooted in the closed innovation mode need to be addressed. The first is the negative value toward using external knowledge, that is, the not-invented-here (NIH) syndrome. The second is a similar negative bias against external exploitation of internal knowledge assets, that is, not-sold-here (NSH) syndrome. Both NIH and NSH attitudes are rooted in a firm's culture (Hussinger & Wastyn, 2016). Understanding the firm's innovation culture is therefore one of the most critical aspects to grasp when changing from a closed to a more open model of innovation (Van de Vrande, Jong, Vanhaverbeke, & Rochemont, 2009).

Business model. A business model under the influence of open innovation may combine elements of the integrated business model (in which a firm assumes responsibility for the entire value chain) with a pure licensing approach (Teece, 2010). In theory, an open business model enables a more effective approach to both creating and capturing value. It captures value in new ways by allowing new sources of revenues on top of a firm's traditional product business through licensing, spin-offs, or direct sales of technology. It creates value by leveraging external ideas and by saving costs and time when using external resources (Chesbrough, 2007).

4.2. Trend #2: A shift from providing physical products to integrated industrial product–services

In recent years, even advanced engineering products have become commodities. In response, companies have started to offer integrated combinations of products and services, referred to as "industrial product–services" (Parida et al., 2014). This transformation or *servitization of manufacturing* moves way beyond side-connected services such as installation and repair to incorporate increasingly complex product–service offers (Cenamor, Rönnberg Sjödin, & Parida, 2017; Khotamäki, Partanen, Parida, & Wincent, 2013).

The successful launch of industrial product–services can allow more stable revenues (Khotamäki et al., 2013), higher profit margins (Ulaga & Reinartz, 2011), and increased inimitability and sales growth. However, servitization might result in an initial performance sacrifice for manufacturing firms, and it has been shown that there are also long-term performance benefits (Visnjic, Weingarten, & Neely, 2014).

Industrial product–services may also be more resistant to economic cycles, which tend to hit up-front purchase of physical products (Baines et al., 2009). Providing industrial product–services is a base for "…a growth strategy on innovation in mature industries" (Mont, 2002). However, a company seeking to pursue such a strategy must change the way it creates, delivers, and captures value and engage in developing new sets of processes, routines, and capabilities (Parida et al., 2014).

Innovation processes. Owing to the high complexity of industrial product–services, the innovation process needs to be inherently flexible and collaborative (Beuren, Gomes Ferreira and Miquel, 2013), and the traditional development of physical products (through stage-gate methodology or equivalent) needs to be integrated or aligned with developing services (Lenka, Frishammar, & Parida, 2015). In particular, as a co-producer of an industrial product–service, the customer becomes involved in ways that diverge from more traditional development (Grönroos & Voima, 2013).

One important condition for an integrated product–service development process is the early integration of customer inputs. As a result, the manufacturing company and its customers form new types of relationships (Baines et al., 2009). Furthermore, an integrated product–service offering changes the locus of value creation, which requires in-depth relationships between manufacturing firms and their customers (Parida et al., 2014). A provider firm may still be responsible for development, manufacturing, delivery, and other activities. At the same time, however, the manufacturing firm and its customers co-create resources, processes, and value through direct interaction (Grönroos & Voima, 2013). This has implications for the stage-gate process, which cannot simply follow the logic of product development, but must also consider how the product is consumed as an integrated product–service offering.

Resources and capabilities. Because industrial product–services are complex, the need for collaboration extends to other partners in the value network also (Lusch & Vargo, 2006). For increasingly complex offerings, the value exchange process benefits from network capabilities for nurturing and coordinating complex relationships. Network capabilities thus enable coproduction of industrial product–services and customer experiences (Khotamäki et al., 2013).

Innovation culture. The servitization of manufacturing brings about a need for cultural changes (Mont, 2002). A service culture differs from that in traditional manufacturing because services are defined in customer-determined benefit terms (Oliva & Kallenberg, 2003). Therefore, manufacturing firms need to abandon product-centric attitudes and instead become more customer centric (Baines et al., 2009).

Business model. Even long ago, manufacturing companies offered agreed-upon services related to a product, although the focus was on selling the product as such and ownership was transferred to the customer (Baines et al., 2009). This is referred to as a product-oriented business model (Reim, Parida, & Örtqvist, 2015). With advanced servitization, new options apply. One is the co-called use-oriented business model, where a product is sold together with services that add value to it, but where ownership of the product remains with the manufacturing firm. Examples include rental or leasing agreements (Beuren, Gomes Ferreira and Miquel, 2013). As a result, the revenues from product sales and maintenance fall dramatically, whereas incomes from monthly licensing increase. Another option is the so-called result-oriented model, where a seller agrees to provide a customer with a certain result or outcome rather than a specific product or service and the customer pays only for agreed-upon results (Reim et al., 2015).

4.3. Trend #3: A shift from an analog world to a highly digitalized one

Approximately 30–40 years ago, advances in IT automated individual activities and unleashed productivity gains, and the advent of the Internet two decades later resulted in yet another major industrial transformation (Frishammar, Parida, & Dasselaar, 2015). These two waves changed value chains across manufacturing industries, but left the *products* as such largely unaffected. Presently, however, we stand at the verge of yet another major transformation, where IT becomes an integral part of products (Porter & Heppelmann, 2014). It has even been proposed that we are entering a "second machine age" (Brynjolfsson & McAfee, 2012), where exponential growth in IT technologies makes smart and connected products technically and economically feasible for mass markets (McAfee & Brynjolfsson, 2012).

New products (and services) emerge as digital components increasingly become embedded in traditional products (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013; Nylén & Holmström, 2015), which has led scholars to predict changes at the level of the task, job, process, and even the organization itself (McAfee & Brynjolfsson, 2012).

Innovation processes. Smart, connected products enable new types of innovation processes. Digitalization speeds up the development process because digital technologies and products can be combined to create hybrid offers (Yoo, Boland, Lyytinen, & Majchrzak, 2012). Furthermore, firms may adopt agile development approaches beyond software development, overturning the well-established stage-gate model. Software also offers completely new possibilities to innovate in a continuous and step-by-step manner through modifications instead of the traditional launch of new products at long intervals.

Digital technologies also enable new groups of stakeholders to take active part in driving development. Manufacturing firms collaborate with new suppliers that create smart, connected products that provide sensors, software, connectivity, analytics, and other technologies (Porter & Heppelmann, 2014). These suppliers bring new knowledge, capabilities, and ways of working to manufacturing firms, which requires revising and adapting traditional product development processes (ibid). Users may also leverage digital technologies, components, or platforms to create products and services beyond original design intentions (Nylén & Holmström, 2015). In a similar vein, digitalized production, along with less expensive hardware and software tools, may allow crowds to better contribute to firms' innovation processes (Baldwin & von Hippel, 2011). This means that a firm relies on broadcast calls to a crowd to have a problem solved or task executed (Bauer & Gegenhuber, 2015), which provides an alternative to both in-house production and designated contractors (Afuah & Tucci, 2012; Jeppesen & Lakhani, 2010). Hence, new demands are put on the innovation process to manage and support a variety of sources for ideas, problems and tasks, and their development and execution.

Resources and capabilities. To cope with digitalization, manufacturing firms need capabilities in nontraditional domains such as software development, systems engineering, and data analytics (Porter & Heppelmann, 2014). This, in turn, can require significant investments in new and specialized competences, as well as different types of infrastructure and technology areas. Digital innovation is also highly recombinant (Nylén & Holmström, 2015), in the sense that each development is a building block for future innovations. In addition to acquiring resources and capabilities needed for primary product development, firms may also consider which resources and capabilities are required to recombine existing innovations into new product offers (Brynjolfsson & McAfee, 2012).

Innovation culture. Previously, product development was a slow and costly activity for manufacturing firms, conducted by specialized groups within marketing and R&D (Cooper, 2008). Digital technologies, in contrast, are omnipresent, thus breaking with traditional roles and responsibilities. Therefore, accommodating digitalization requires an innovation culture characterized by improvising, rather than central control and planning (Nylén & Holmström, 2015). Adding new talent in software development, big data analytics, and other areas may also call for a more service-

centered (rather than product-centered) culture (Porter & Heppelmann, 2014).

Business model. When products become increasingly smart and connected, they allow access to streams of product data, which results in new business models. Moreover, this also boosts the ability to reduce and repair a product's problems. This affects both performance and design services. Whereas traditional business models (transfer of ownership) may be retained, digitalization allows for new result-oriented business models to emerge, where customers pay as they go rather than up front (Porter & Heppelmann, 2014). For example, General Electrics' revenues from jet engines are no longer associated with sales transactions but with performance improvements (Iansiti & Lakhani, 2014).

5. Auditing innovation in the light of current trends

Openness, servitization, and digitalization are transforming innovation management practices in manufacturing firms. Managers who overlook these trends risk making two types of errors. The first type of error is that of overlooked opportunities. Managers who do not see the impact of openness, servitization, and digitalization may fail to adapt to changes in their environment, thereby undermining the competitive positions of their firms. The second error is that of underestimated challenges. That is, managers may rush ahead and change their innovation management practice without carefully considering the challenges they imply. Either way, a failure to audit innovation in the light of these trends may lead to loss of competitive advantage.

In this section, we present an updated innovation auditing framework. This framework highlights both opportunities and challenges that arise because of openness, servitization, and digitalization, and we provide critical questions managers must ask when auditing innovation in this changing innovation landscape. Table 3 provides a visual overview of our framework.

5.1. Transforming the innovation process – opportunities and challenges

An innovation process that accommodates openness, servitization, and digitalization requires major transformations—from cultivating internal ideas into implementation, to an open and distributed process that combines product/service development. Such a transformation requires extended use of innovation networks, or external innovation ecosystem stakeholders. This is particularly critical for firms that seek to accommodate digitalization, as this allows new forms of collaboration among partners and customers. In a similar vein, customers and other cocreators need to be involved early, at the front-end stage of the innovation process. To manage an extended value network, many firms use innovation intermediaries to help facilitate technology transfer.

Promising opportunities arise: the innovation process can be made more adaptive, faster, and more customer-oriented (Chesbrough, 2006). As a result, the innovation process is better suited to identify novel ideas, improve idea selection, and develop new products and services that are at the core of what customers are requesting through rapid and iterative feedback loops. It also becomes easier to target subject-matter experts and engage with communities of suppliers and customers.

But there are also challenges. Complexity increases when firms need to manage multiple projects in different ways, rather than having one streamlined and standard stage-gate way of doing things. Coordination costs increase, as a focal firm must manage multiple stakeholders ranging from suppliers to customers and end-users; all of which have an impact on the products/services being developed. In addition, the cognitive burden increases as managers need to scan, interpret, and access diverse and multiple knowledge components from a broad external environment (Cassiman & Valentini, 2015). This is problematic, as cognitive capacity is a limited resource (Kahneman, 1973). It is not self-evident that a larger number and more diverse set of ideas from external actors results in better decision-making or, for that matter, better innovations. Instead, evidence is present that the effect of openness is curvilinear. This means that beyond a certain optimal point, the value of openness drastically decreases (Laursen & Salter, 2006). Many firms also find it difficult to deal with unsolicited ideas that often come in high quantity and low quality (Alexy, Criscuolo, & Salter, 2012). Moreover, using ideas from external parties may be more difficult than using ideas from internal sources.

In addition, when a firm opens its boundaries in different ways, it runs the risk of knowledge leakage, that is, losing core knowledge and technology that it intended to keep (Frishammar, Ericsson & Patel, 2015). For many firms, it is difficult to find the appropriate balance between trust and knowledge exchange on the one hand, and control and protection on the other (Brattström & Richtnér, 2014). Another challenge is the so-called service paradox, thus implying that firms add services that cause costs to products but fail to reap full benefits of both their product and service offerings, as revenues do not materialize.

5.2. Transforming innovation Resources and capabilities – opportunities and challenges

To benefit from openness, servitization, and digitalization, new resources and capabilities are needed. These are related to specialized knowledge in new technology areas, as well as resources and capabilities for coordinating and integrating customers, suppliers, and other external actors into the innovation process. Finally, demands increase for software development, systems engineering, and data analytics, areas that manufacturing firms have hardly seen as their historical core competences.

Many benefits can be realized. By opening a firm's boundaries to the outside world, there will be an improved inflow of information and contributions from partners. Firms can thus improve their use of external knowledge, which may eventually help them develop products with greater novelty and variety, speed up the development process, and stay tuned into and knowledgeable about a broader range of technology areas. Moreover, digitalization presents new ways to engage with customers. This allows manufacturing firms to increase customer input, as well as educate and teach customers what the firm is doing and developing.

Yet, there are some critical challenges. Developing new resources and capabilities is a long and complex process, with uncertain outcomes. Incumbent, large firms, in particular, have been found to struggle with such changes. In addition to learning new skills and habits, firms may need to unlearn old habits and change routines regarding how they do things, which is far from a simple task. Another challenge is talent management. What competences are needed in the new innovation landscape? What competences are not needed? Furthermore, as firms undertake several new and different tasks, variability and complexity inevitably increase. This may lead to a low use of resources, thereby leading firms to being both ineffective and inefficient. Given the costs associated with adapting, changing, and unlearning, it may very well be that some firms are better off not rushing blindly ahead to follow a trend, but to stay firmly rooted in what they already know and do best. Another potential problem is the possible collision between different development regimes in hardware and software, which can be difficult to merge. Combining different paces and development logics is far from straightforward and can render coordination overly complex and thus costly.

Table 3
New practices, opportunities, and challenges in a new innovation landscape.

Audit Dimension	Transformations from openness, servitization, and digitalization	Opportunities	Challenges	Innovation audit questions in the new innovation landscape
Innovation process	Ideas are increasingly brought in and spun-out to external actors. This implies that customers and innovation intermediaries play a more prominent role in firms' innovation processes, and that a firm-centric view of innovation processes is replaced by an eco-system oriented view.	• More customer-centric innovations • Faster and more adaptive innovation process • Better use of subject-matter experts • Better engagement with communities of suppliers and customers	• As complexity increases, cognitive costs and coordination costs may increase disproportionally. • Risk for knowledge leakage – loss of strategic knowledge to competitors. • Service paradox – new service development results in higher costs but not higher revenues	• Do you have an understanding of the key actors in your innovation eco-system? What they want, can, and will contribute with? • Do you have the collaborations with partners and customers you need? Have you prepared for collaborations that will be important in the future? • Do you have the skills to co-create innovations with customers and partners at early stages in the innovation process? • Can you create new value streams, such as by using innovation intermediaries to facilitate technology transactions? • Is your innovation process sufficiently flexible and agile? • What are your coordination costs and how do you keep track of them over time?
Resources and capabilities	Firms need new capabilities to manage inbound and outbound technology transactions, crowd sourcing, and customer co-creation. There is also an increased use of new resources for software development, systems engineering, and data analytics	• Increased inflow of valuable information and knowledge • Increased utilization of external (and internal) knowledge • Deeper engagement with customers allows technology push when customers are "taught" new solutions • Opportunity for greater novelty and variety in products and services	• Core capabilities may turn into core rigidities as the environment changes • Deficient learning processes and need for "unlearning" • Hollowed efficiency and effectiveness when trying to do too much • Deficient capabilities to meet required levels of participation and collaboration with stakeholders in the ecosystem	• What would be the implications of broadening your capabilities to a larger number of areas, vs. narrowing your focus to what you do best? • Do you have the resources and capabilities you need to coordinate and integrate customers, suppliers, and other external actors into the innovation process? • Do you have the specialized knowledge needed in new technology areas such as software development, system engineering, and data analytics? • Can you create new values by engaging with customers through digital technologies? • How do you routinize for using internal knowledge externally to help your partners?
Innovation culture	The innovation culture needs to embrace external collaboration, especially overcoming not-invented-here and not-sold-here syndromes. Innovation becomes a task for the whole firm, requiring a culture of innovation that transcends the R&D lab	• Establishing a customer-centric culture • An organization-wide attention to innovation; removal of "silo-thinking" inside the firm • Openness to external ideas and new thinking	• Lack of cross-functional competence • Failing to sustain different subcultures – some exploratory and some exploitative – to accomplish different goals • Loss of efficiency and exploitation in current domains when the whole firm focuses on exploration of new opportunities	• How do you secure a culture of openness? • Do you conduct innovation experiments, and do you benefit from them? • How do you value ideas and insights that originate outside your organization? • How can you create the view that innovation is an organization-wide concern, i.e. that everyone is responsible for innovation? • Is your firm customer-centric in all aspects of work? • What strategies and routines do you have for both integrating and separating functions and departments?
Business model	Changed locus of value creation and value capture implies an increased reliance on use-oriented and result-oriented business models. Possibility to license out technology, complementing traditional path of product/service commercialization	• New sources of revenues, and more stable revenues • Opportunity for increased automation • A focus on customer experience and customer "journey" create commitment and support from customer and supplier communities	• Traditional revenue streams from up-front sales disappear or diminish • Technology out licensing may undercut a firms product business • New business models can take time and energy to implement	• Do you have the knowledge to implement customer-centric business models? • Are your firm's processes for value creation and value capture deeply integrated with customer activities? • How do you understand and manage dependencies with customers? • How do you develop customer "journeys" that add value? • Are you exploring and exploiting opportunities to create new sources of revenues along the whole value chain?

Another major challenge is how a firm balances, on the one hand, what is an optimal solution for the firm itself in terms of capabilities and resources and, on the other hand, what is an optimal solution for the ecosystem as a whole. The increased reliance on external parties also implies a relative shift in importance from technological capabilities to relational capabilities (Lorenzoni & Lipparini, 1999), thus allowing for effective collaboration with, for example, suppliers, customers, and communities.

5.3. Transforming innovation culture – opportunities and challenges

Openness, servitization, and digitalization have a direct impact on the values, norms, and beliefs in a firm. For example, firms need to nourish a culture of openness and flexibility, one in which information from outsiders is assimilated instead of rejected. Customers' use of the product should be seen as a vital part of the early development stages, rather than simply the end user. Finally, as the product–service offering becomes integrated and digitalized, innovation increasingly crosses functional and organizational hierarchies. Instead of being a concern for the engineers in the corporate R&D lab, innovation becomes an organization-wide concern for all of the firm's members.

One potential opportunity from transforming the innovation culture is a more customer-centric firm. This increases the likelihood that customers will seek out a new product and service offerings and reduces the risk that the manufacturing firm pushes out products and services that customers are unwilling to pay for. At the same time, an excessive focus on existing mainstream customers and related product and service performance dimensions may lead firms to miss out disruptive innovations (Christensen, Olesen, & Kjaer, 2005). Another potential opportunity is a richer and more creative soil for innovation, as this activity becomes the responsibility of all functions within the firm, rather than something completed mainly by R&D. When the expertise and knowledge of different functions are integrated, new opportunities for innovation are likely to arise. However, excessive heterogeneity can bring about negative effects as communication and knowledge exchange are hampered (Milliken & Martins, 1996).

Changing the culture also brings about trade-offs. Shared responsibility can become no one's responsibility: when innovation becomes an organization-wide concern, there is a risk that no single function will ensure that innovation actually occurs. Handling this issue requires productive ways of working with goal setting and related performance measurement and management (Richtnér et al., 2017). By making innovation ambitions and goals explicit, the possibility to allocate resources and time to innovation activities is facilitated even if these activities are distributed throughout the organization and sometimes also take place outside of it.

There is also a trade-off between cross-functional integration and specialization. For example, most firms want to explore radical opportunities, while at the same time benefiting from exploiting more incremental innovations. One way to accomplish both objectives is to separate tasks among different organizational groups (Tushman & O'Reilly, 1996). This allows for some groups to nurture a more explorative culture, whereas other groups will nurture a more exploitative culture. Firms that seek to establish both trust and control regarding external R&D partners may also gain from separating, rather than integrating, groups. This allows for some groups (e.g., the purchasing function) to take the role of “bad cop” in a relationship, whereas another group (e.g., the R&D unit) maintains a trust-based, “good cop” relationship with the partner (Brattström & Richtnér, 2014). At the same time, the resulting differentiation may easily lead to suboptimization and a lack of realized synergies, if suitable integration mechanisms are not in place.

5.4. Transforming the business model – opportunities and challenges

Accommodating openness, servitization, and digitalization has implications for the business model of a manufacturing firm. Traditional business models are being replaced with use-oriented or result-oriented models (Reim et al., 2015). With such models, the firm's processes for creating and capturing value are deeply integrated with customers' activities. Consequently, profits may arise in new places in the value chain.

The opportunity here is an improved offer to the customer, personalization of the offer to the market, and more stable revenues. For example, firms are increasingly developing customer journeys with several touch points between the firm and the customer (see e.g., Edelman & Singer, 2015). These touch points can be used to identify new ways to generate revenues. In addition, new sources of revenues may materialize through, for example, technology licensing, and revenues may also be more equally distributed over industry up- and downturns.

At the same time, there are key challenges associated with these transformations. Traditional revenue streams from up-front sales can be disrupted or might even disappear. Outcome-based business models also create new dependencies where the customers' ability to operate successfully has a clear and direct impact on a focal manufacturing firm (Iansiti & Lakhani, 2014). In addition, implementing a new business model takes both time and energy and may not give an immediate payback (McKelvie, Brattström, & Wennberg, 2017). Finally, a firm that starts to license technologies risks undercutting its product business, thus creating profits in one dimension, while at the same time undermining another. The licensing model works only if there are strong intellectual property rights; otherwise the manufacturing firm will have great difficulties capturing value (Teece, 2010).

5.5. Questions to ask when auditing in the new innovation landscape

The identified implications of Openness, Servitization, and Digitalization on the key innovation audit dimensions require a new set of innovation audit questions. Table 3 provides a set of such questions, with the intent to be useful for managers when auditing innovation in the light of current trends. The trends, however, also imply a need to rethink how an innovation audit is conducted. Previous innovation audits have focused on collecting responses to questions in both quantitative and qualitative ways, often following an expert approach where the outcomes were analyzed in comparison with reference scores or best practice cases. Auditing innovation in the new innovation landscape, however, requires a different approach, more in line with a learning approach to auditing (Brattström, Frishammar, Richtnér & Pflueger, in press).

As Table 3 indicates, openness, servitization, and digitalization demand a more holistic and outward-focused approach to innovation, as it requires improved understanding of what firms can and should do, how it is done, and with whom in the innovation ecosystem. The focal firm may still be the key unit of analysis, but ecosystem influences are equally important to understand. For example, a firm needs to know what other stakeholders are operating in the ecosystem, what they want, what they do and do not do, their individual contributions, and so forth. The quality of auditing increases if these collaborating firms share information with the auditing firm, and if feasible, even actively participate in auditing work.

Increased digitalization implies that innovation becomes a more continuous and distributed phenomenon, taking place in small steps rather than bold leaps. On the one hand, this may render innovation more difficult to observe, and also make it more difficult to relate specific innovation actions to effects. On the other hand, the digitalization of innovation activities may actually make them more visible and traceable as more process data are generated and stored. Moreover, as products and services are composed of a larger number of components, supplied by a broader set of firms and exhibiting a more diversified set of technologies, questions of intellectual ownership arise. It may become increasingly difficult to determine exactly what and who is behind the success of a specific innovation, thus making distribution of costs and revenues among collaborating parties more challenging. As the link between innovation input, activities, and output becomes ambiguous, auditing of innovation becomes more challenging and might require a more qualitative, rather than quantitative, set of measures. In contrast to this background, Table 3 provides a starting point for improved innovation auditing practices as the innovation landscape is transformed, and these are to be used with the outlined opportunities and challenges presented for each trend.

6. Conclusions and limitations

Existing innovation audit frameworks do not consider the profound impact of openness, servitization, and digitalization. By assessing and synthesizing existing innovation audit frameworks from academia and practice, and by studying the challenges of three global manufacturing firms, we have identified four key innovation audit dimensions and then discussed the audit implications for each of these dimensions. We conclude that openness, servitization and, digitalization bring about both opportunities and challenges. Auditing innovation in the light of these trends, therefore, requires a reassessment of firm-specific trade-offs.

We contribute with an analytical framework and a set of questions for auditing innovation in light of the observed trends. For theory building, we have discussed a number of relevant issues and contingencies to decision-making, which are not covered by extant frameworks. We have discussed, for example, how the three trends increase the complexity of the innovation process, thus leading to an increase in both cognitive costs and coordination costs. As another example, we have discussed how openness and digitalization lead to a reliance on more heterogeneous innovation ecosystems, thus implying a need for an increasingly open innovation culture, more advanced relational capabilities, and more agile innovation processes. Moreover, it is clear that an augmented customer orientation and the resulting strengthening of relations to established customers may increase the risk of missing out on disruptive innovation. Altogether, the described trends change utility considerations for managers, thereby prompting them to consider a novel set of contingencies in their strategic decision-making processes.

Our suggested audit framework can help firms to complement and improve existing innovation auditing practices, thus allowing managers to assess and evaluate their innovation activities more effectively against the new innovation landscape. As such, it may help firms and managers improve innovation auditing and, by extension, improve innovation management.

Yet, some words of caution apply. Although the audit framework focuses on key audit dimensions, other dimensions may also be relevant, such as manufacturing processes or support systems. By extension, the three identified trends may also generate implications not fully covered by our analysis. For example, pursuing open innovation in increasingly open ecosystems may require a firm not only to audit itself but also by extension to perform audits on its core partners, or it may even require establishing joint innovation audit routines together with other firms. For example, managers may want to better understand the absorptive capacity of recipient firms. Additionally, while the framework was tested with industrial firms through workshops, large-scale testing has not been conducted, which limits generalizability of our findings.

Moreover, although our study addresses how the identified innovation trends impact innovation auditing frameworks for manufacturing firms in general, we have not addressed differences between pure service providers and manufacturers with complementary service offers. Similarly, there may be industry idiosyncrasies at play, as manufacturing industries contain a variety of different subsegments and types of firms. Investigating innovation auditing differences for different types of firms, as well as differences in the impact of the three trends is also an interesting area for further studies.

Finally, our suggested amendments to established innovation audit frameworks should not be interpreted as advising firms to simply do more of everything. At an overall level, we observe that innovation efforts are growing. For example, the use of open innovation does not imply that internal R&D is unimportant, and the servitization trend does not undercut the importance of physical products. Therefore, an overall key challenge is to distribute limited cognitive resources and attention to where they matter the most.

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