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Will Algorithms Replace Managers? A Systematic Literature Review on Algorithmic Management

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Abstract

Algorithms increasingly take on tasks traditionally performed by humans. They not only serve as co-workers to their human counterparts but increasingly take over management tasks by supervising and coordinating human workers – a phenomenon referred to as Algorithmic Management (AM). There is a growing research interest in this topic, but currently, the field lacks an overview and thorough understanding of what types of managerial work algorithms already perform. We address this with a structured literature review. We find that the automation of management work and workers' responses to it (so-called algoactivism) have received the most attention. However, the configuration of AM systems has so far received little systematic attention. We further analyze which management functions algorithms perform. We find that while algorithms primarily supervise and investigate workers, coordinating interdependent workers and tasks has not been addressed. We propose several avenues for future research.

Keywords: algorithmic management, management, automation, coordination

Introduction

Organizations increasingly make use of algorithmic management (AM), that is, they employ algorithms that "carry out coordination and control functions traditionally performed by managers" (Möhlmann et al., 2021, p. 2001). As AM requires the "large-scale collection and use of data" (Möhlmann et al., 2021, p. 2001), it is mostly used on digital labor platforms, such as Uber, where detailed data on the execution of work is readily available and where AM allows to coordinate a large workforce efficiently (Benlian et al., 2022; Wiener, Cram, & Benlian, 2021). In Europe and in the US already today, platforms coordinate a workforce of more than 180 million independent workers and are quickly growing (Chan & Wang, 2018; Manyika et al., 2016). With the ongoing datafication of organizations, AM is expected to increasingly impact more traditional sectors and organizations as well (Benlian et al., 2022; Wurm et al., 2023), and it "is becoming a key part of AI-driven digital transformation in companies" (Jarrahi, Möhlmann, & Lee, 2023, p. 1).

At its core, AM captures "the execution of coordination and control tasks with little to no human involvement" (Benlian et al., 2022, p. 825). From a socio-technical systems perspective (Sarker et al., 2019),

AM encompasses at least three additional aspects. First, from a technical angle, AM requires the generation of datasets and the configuration of algorithms for decision-making (Möhlmann et al., 2021). Second, in most cases, algorithms do not make decisions autonomously but *informate* managerial decision-making (Cram & Wiener, 2020). Third, while AM offers many advantages, it also entails severe downsides, such as increased technostress of workers (Cram et al., 2022), lack of autonomy (Wiener, Cram, & Benlian, 2021), and role conflict associated with low well-being (Tarafdar, Page, & Marabelli, 2022). As a result, employees have started to engage in algoactivism, that is, practices to influence or manipulate algorithms (Jiang, Adam, & Benlian, 2021; Kellogg, Valentine, & Christin, 2020).

The body of research on AM is rapidly growing, but a comprehensive overview of the management tasks performed by AM systems is currently missing. Previous reviews on AM have omitted specific management aspects (Heinrich, Vu, & Vysochyna, 2022) or have concentrated on algorithmic control and coordination (Lippert, Kirchner, & Wiener, 2023), neglecting other important tasks that managers perform. Although management functions and tasks go beyond mere control (Tsoukas, 1994), research has not taken this into account, let alone given a comprehensive overview. To address this research gap and to provide a common knowledge base for research on AM, we pursue the following two research questions:

RQ1: What is the current state of research on Algorithmic Management?

RQ2: Which managerial functions are automated by algorithms?

To answer these questions, we conduct a systematic literature review following the guidelines of vom Brocke et al. (2009). Overall, we analyzed 688 articles from information systems (IS) and related fields to capture different perspectives on AM and to cover this subject comprehensibly. To assess the literature, we draw on two frameworks. First, we extend the framework on AM by Benlian et al. (2022) and describe how its six dimensions (e.g., automation of decision-making and workers' resistance against algorithmic decisions) have been discussed in the literature. Second, we unpack the literature on AM by means of the so-called SPICES (supervising, planning, investigating, coordinating, evaluating, staffing) classification of managerial functions (Carroll & Gillen, 1987). Using the SPICES classification as a conceptual lens allows us to understand which managerial functions have been discussed in the literature and to identify functions that have not yet received much attention. Our study contributes to the emerging stream of literature on AM by outlining the state of the art, pointing to limitations, and deriving directions for future research.

The remainder of this paper is organized as follows. First, we explain the key aspects of AM and outline the different functions that managers perform. Second, we explain how we conducted our literature review. Third, we present the findings of our literature analysis. Fourth, we discuss the implications and limitations of our work and propose a framework for future research. Finally, we conclude the paper by summarizing its key contribution to the body of knowledge.

Research Background

In this section, we outline the research background against which we position our work. First, we outline the research on AM and how it relates to traditional management and decision support systems. We then explain the different functions that managers perform as they can serve as an alternative to the control-centric perspective in the AM literature.

Algorithmic Management

Novel "computing systems fundamentally challenge our long-held beliefs about what falls into the realm of human ability and what is machine capability" (Schuetz & Venkatesh, 2020, p. 461). This does not only pertain to how workers perform tasks but increasingly leads to AM, that is, algorithms performing managerial work. AM "is a typical example of a modern-day application of artificial intelligence (AI) and one that is likely to stay and grow in the future" (Benlian et al., 2022, p. 831).

To explain how AM relates to traditional management and decision support, we draw on the framework proposed by Benlian et al. (2022), as depicted in Figure 1. The framework comprises three agents: 1) human managers, 2) the algorithm, and 3) the human worker. Traditionally, human managers carry out different types of *management* work, which might lead to *feedback* from supervised workers. In order for information technology (IT) to support or act instead of managers, algorithms and supportive IT

infrastructure needs to be *configured*. These algorithms then either *inform* or *automate* managerial decision-making. One example of the informating of management practices is people analytics. It encompasses the use of "computational techniques [to] leverage digital data from multiple organizational areas to reflect [...] behavior" and provides decision-makers an overview of processes, resources, and people through an IS (Gal, Jensen, & Stein, 2020, p. 1; Huselid, 2018). To highlight that algorithms do not take decisions but only provide suggestions, the arrow in Figure 1 is dashed. In contrast to people analytics and decision support systems (Turban and Watkins 1986), AM systems make management decisions autonomously, i.e., they automate managerial work.

AM nudges, gives advice or guides workers in a way that aligns their actions with the overall company's objectives (Cram & Wiener, 2020; Kellogg, Valentine, & Christin, 2020). The term AM was originally introduced by Lee et al. (2015), who define it as "software algorithms that assume managerial functions and surrounding institutional devices that support algorithms in practice" (Lee et al., 2015, p. 1603). Möhlmann et al. (2021) proposed a different definition describing a combination of data collection and use with the goal of fostering complex learning algorithms to carry out managerial functions (Benlian et al., 2022; Möhlmann et al., 2021). Specifically, they define AM as "the large-scale collection and use of data on a platform to develop and improve learning algorithms that carry out coordination and control functions traditionally performed by managers" (Möhlmann et al., 2021, p. 2001). While this definition explicitly includes the term "platform", AM is expected to considerably impact management and decision-making in traditional businesses as well, independent of the work context and the tasks to be performed (Benlian et al., 2022; Kellogg, Valentine, & Christin, 2020; Wurm et al., 2023).

Möhlmann et al. (2021) differentiate two dimensions of AM: algorithmic matching and algorithmic control. Algorithmic matching captures how platforms coordinate the demand and supply of labor in the form of both knowledge and physical labor. Because a platform is a digital version of a market, balancing supply and demand efficiency is critical to the success of its business model. The platform also builds on network effects that drive the platform's value, as it can only serve customers well if the number of existing providers (for example, drivers) can satisfy the demand. Whereas algorithmic matching is focused on market coordination, algorithmic control focuses on monitoring worker behavior to ensure alignment with the goals of the platform. Algorithms act as "bosses" on the platform because they control the work the drivers perform. This is, however, only possible through the precise collection and use of process data to monitor workers (Möhlmann et al., 2021). This data is, for example, used to learn workers' behavioral patterns and nudge them to optimize operations (Möhlmann et al., 2021).

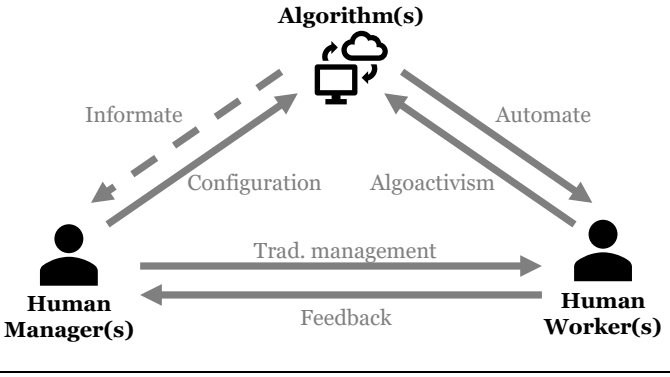

Figure 1. Algorithmic Management Framework (extended from Benlian et al. (2022))

Because most platforms do not disclose information on how their AM systems function, workers often perceive them as "black boxes" (Möhlmann, Salge, & Marabelli, 2023, p. 36). Human workers nevertheless try to make sense of AM, e.g., by seeking information about the algorithm or testing how actions translate into rewards or sanctions (Möhlmann, Salge, & Marabelli, 2023). It has been found that workers' perception of the legitimacy of AM plays a large role in their willingness to continue working on a platform or engage in workarounds (Wiener, Cram, & Benlian, 2021). More generally, when workers suffer from adverse effects of AM, such as lack of autonomy (Wiener, Cram, & Benlian, 2021) and role conflict (Tarafdar, Page, &

Marabelli, 2022), they engage in algoactivism, that is, individual and collective strategies to circumvent, cheat or manipulate the respective algorithm (Kellogg, Valentine, & Christin, 2020).

So far, three reviews were conducted in the broader context of AM. First, Heinrich, Vu and Vysochyna (2022) build on a structured literature review to create a taxonomy of AM. Their taxonomy comprises the seven dimensions: 1) mechanisms of AM, 2) effects of AM, 3) second party's responses to AM, 4) concerns around AM, 5) design of AM, 6) policy implications of AM, and 7) "others". While their paper provides a good overview of the various topics associated with AM, it does not take into account the role of management functions as well as specific dimensions of the framework proposed by Benlian et al. (2022), such as the configuration of AM. Second, the review by Lippert, Kirchner and Wiener (2023) categorizes 45 papers on AM into six control mechanisms outlined by Kellogg, Valentine and Christin (2020). They further differentiate the underlying work context, i.e., they differentiate whether work takes place in the context of a platform, traditional or hybrid context to derive seven usage patterns of AM. Third, Parent-Rocheleau and Parker (2022) approach the topic from a human resource management perspective. Based on a conceptual review, they identify six human resource management functions that AM performs (monitoring, goal setting, performance management, scheduling, compensation, and job termination) and analyze how these functions influence job resources and job demands (Parent-Rocheleau & Parker, 2022). Two management functions are excluded (training and career management) from their model, and because their management functions are not based on a systematic review, it seems likely that other important aspects are not considered. To address these limitations, we take a step back and use the established management literature to analyze the managerial functions that algorithms carry out. We explain these managerial functions next.

Managerial Functions: What Do Managers Do?

On the most abstract level, management can be conceptualized as causal powers, also referred to as control (Tsoukas, 1994). According to this perspective, managers are "agents of capital" (Tsoukas, 1994, p. 294) whose main task is to control work processes to ensure optimal labor utilization. This perspective provides the foundation for the labor process theory in which management uses control (technologies) to maximize labor output (Braverman, 1974; Kellogg, Valentine, & Christin, 2020). Research on AM relies on this perspective, as digital technologies enable ever-new ways to exert control on workers (Kellogg et al. 2020).

Function	Definition
Supervising	"Directing, leading, and developing subordinates. Counseling subordinates, training subordinates, explaining work rules, assigning work, disciplining, handling complaints of subordinates."
Planning	"Determining goals, policies, and courses of action. Work scheduling, budgeting, setting up procedures, setting goals or standards, preparing agendas, programming."
Investigating	"Collecting and preparing information, usually in the form of records, reports, and accounts. Inventorying, measuring output, preparing financial statements, recordkeeping, performing research, job analysis."
Coordinating	"Exchanging information with people in the organization other than subordinates to relate and adjust programs. Advising other departments, expediting, liaison with other managers, arranging meetings, informing superiors, seeking other departments' cooperation."
Evaluating	"Assessment and appraisal of proposals or of reported or observed performance. Employee appraisals, judging output records, judging financial reports, product inspection, approving requests, judging proposals and suggestions."
Staffing	"Maintaining the workforce of a unit or of several units. College recruiting, employment interviewing, selecting employees, placing employees, promoting employees, transferring employees."

Table 1. Dimensions and Definition of Management Functions (Carroll & Gillen, 1987; Mahoney, Jerdee, & Carroll, 1965)

While this perspective is useful to understand managements raison d'être, it is too abstract to inform about the different tasks that managers carry out and that might be automated by AM. To understand the work that managers perform, we need to understand "what these individuals regularly do" (Tsoukas, 1994, p. 289). Henry Fayol first described the foundational set of activities that all managers perform (Fayol, 1917).

Having lived and worked as a manager in the early 1900s, Fayol conceptualized his observations of the mining business in his book "Administration Industrielle et Générale" (Fayol, 1917), later introduced to the international scientific community as "General and Industrial Management" (Fayol, 1949). He conceptualized his observations in the basic functions of management, which are today known as the *functional* or *process perspective* of management (de Oliveira et al., 2015).

The functional perspective outlines the fundamental tasks that all managers perform (de Oliveira et al., 2015). It describes elementary functions of management (Carroll & Gillen, 1987; Mahoney, Jerdee, & Carroll, 1965) that are not bound to specific industries or types of organizations (Lamond, 2004). Mahoney, Jerdee and Carroll (1965) and later Carroll and Gillen (1987) further developed the functions proposed by Fayol (1949) and tested them empirically. Specifically, Carroll and Gillen (1987) summarize managerial work in the SPICES framework that comprises supervising, planning, investigating, coordinating, evaluating, and staffing as the most important managerial functions (Carroll & Gillen, 1987). Today, the SPICES framework is one of the most established conceptualizations of management. Recently, the framework has been employed to analyze management in highly competitive environments (Bouty & Drucker-Godard, 2019) and the work of small business owners (de Oliveira et al., 2015), amongst others. Table 1 provides the definition for each dimension of the SPICES framework.

It is important to note that the term "coordination" is used differently in the context of platforms (Möhlmann et al., 2021) compared to the classical management functions (Fayol, 1949). In the platform context, coordination encompasses matching supply and demand on the platforms and assigning tasks to individuals (Möhlmann et al., 2021). However, coordination as a classic management function aims to provide an informational infrastructure (Bouty & Drucker-Godard, 2019) to facilitate the exchange among peers and with supervisors. It ultimately ensures that different tasks feed together into a product or service.

We argue that the SPICES framework is useful to examine the managerial functions performed by AM systems. In particular, it allows us to deviate from a mere control-centric perspective on AM (Cram et al., 2022; Kellogg, Valentine, & Christin, 2020; Wiener, Cram, & Benlian, 2021) and consider the automation of managerial work in its full breadth. Together with the AM framework (Figure 1), we will use the SPICES framework as an analytical lens for our literature analysis.

Method

To answer our research questions, we conduct a systematic literature review following the guidelines of vom Brocke et al. (2009). First, we conceptualized AM as presented in the theoretical background. Second, we defined the scope of our review using Cooper's (1988) taxonomy for literature reviews along the categories of (1) focus, (2) goal, (3) perspective, (4) coverage, (5) organization, and (6) audience. Third, we conducted the search for literature. Fourth, we analyzed the literature. Finally, based on the insights from our review, we derived a framework for future research. Figure 2 summarizes the literature review process.

In terms of Cooper's (1988) six dimensions of literature reviews, our review can be positioned as follows. (1) Our literature review focuses on AM. (2) Our goal is to synthesize the literature on AM and point to future research. (3) Our perspective is neutral, as we do not argue for either perspective on the subject to be superior to the other. (4) We conduct our analysis in an exhaustive fashion, considering a wide array of conferences and journals across different fields. (5) The organization of our review is conceptual, as we classify and analyze the literature based on existing concepts. (6) The target audience for our review is researchers in IS and researchers in AM, regardless of the discipline they identify with.

For the literature search, we used the search terms "algorithmic management", "algorithmic control", "algorithmic matching", "algorithmic governance", "algorithmic planning", "algorithmic organization", "algorithmic command", "algorithmic coordination", "automate management", "automate control", "algorithm management" and "algorithm control". We employed these terms to search titles, abstracts, and keywords within the most important databases for IS (Ebscohost, Web of Science, and Association of IS (AIS) Library) and the senior scholar list. Additionally, we conducted a forward and backward search to identify relevant articles that were not directly identified through our keyword search. This search yielded 688 results, of which 212 (30.8%) were duplicates, leaving us with 476 unique articles.

Next, we reviewed the articles' abstract, introduction, and findings based on pre-defined inclusion and exclusion criteria as proposed by Okoli (2015) and Schryen et al. (2020). We specified our inclusion criteria

to ensure that all articles adhered to a certain scientific standard that we defined as follows: (I1) the article must be written in English, and (I2) it must have undergone peer review.

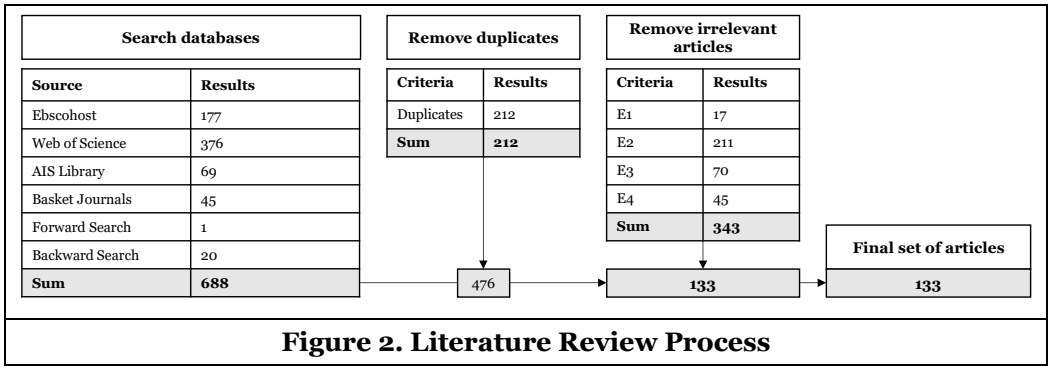

Figure 2. Literature Review Process

Our exclusion criteria aimed to guarantee topic fit and high quality of selected papers. First, (E1) we disregarded all papers we could not access (17 of initial search hits) from our further analysis. Second, we excluded (E2) work that does not relate to AM in the broad sense of Möhlmann et al.'s (2021) definition, noting that we were liberal in our interpretation of this criterion to include a maximum of diverse work. The term "algorithmic control" is used in a different context by the disciplines of medicine, psychology, mathematics, computer science, and chemistry, among others. We excluded these articles in line with E2. Third, we excluded work (E3) that was not socio-technical in its nature. We thus excluded work that, for example, treats purely legal or political aspects of AM. Finally, we excluded work that was (E4) an editor's comment, a special issue introduction, a book, a book review, a teaching case, or does generally not qualify as a research paper. A final set of 133 articles (19.3% of initial hits) remained for the literature analysis.

After deriving our final set of articles, we studied each paper in detail. To ensure reliability, two authors coded a random set of ten studies that were then discussed. We then adjusted the coded categories. The first author coded the remaining articles and discussed the results regularly with the second author. To understand the state of the art in AM literature (RQ1), we followed Schryen et al. (2020) and synthesized the existing literature by applying a new perspective (Schryen et al., 2020). Based on the framework in Figure 1, during coding, we first determined whether a paper addressed traditional management, feedback, configuration, informating, automation, or algoactivsim. Then, we assessed which management functions the discussed algorithm performed using the definitions provided in Table 1. We collected our findings in a concept matrix following Webster and Watson (2002) that we used to answer our research questions. The coded dataset is available for download as a concept matrix at the following URL (https://github.com/T4gmaster/ICIS2023_1298).

Findings

In this section, we present the findings of our literature review. We first outline the state of the art of research on AM based on the framework extended from Benlian et al. (2022) that we presented in Figure 1. Afterward, we use the management functions of Carroll and Gillen (1987) to analyze in detail which managerial functions are performed by AM as documented in the literature.

The State of the Art in Research on Algorithmic Management

Figure 3 visualizes the development of AM research over time, distinguishing between articles in the senior scholar list, papers at AIS conferences, and other outlets. The figure shows that the number of papers published has steadily increased, with the IS domain contributing 29% of all papers. Although Lee et al. (2015) coined the term AM, the first relevant articles go back to the work of Cox and Clark (1984), who discuss the design, implementation and operation of manufacturing resource planning systems that automatically create personnel plans, among others (Cox & Clark, 1984). We chose not to depict four outliers in the years 1984 to 2002 (of which two are from the senior scholar list) for visualization purposes, and the six articles for 2023 (one in the senior scholars list, two in AIS conferences, and three others) because the academic year is still ongoing. The topic has only gained traction in IS with the International Conference on IS Proceedings in 2017. Gal et al. (2017) propose a research agenda for "application[s] of

algorithms to manage people" (Gal, Jensen, & Stein, 2017, p. 1), and Möhlmann and Zalmanson (2017) conduct a study of Uber drivers' reactions to AM. Outside of IS, the probably most influential publication is Kellogg et al.'s (2020) discussion of algorithmic control. They discuss technologically induced dynamics in the manager-worker relationship and propose six types of algorithmic control (Kellogg, Valentine, & Christin, 2020).

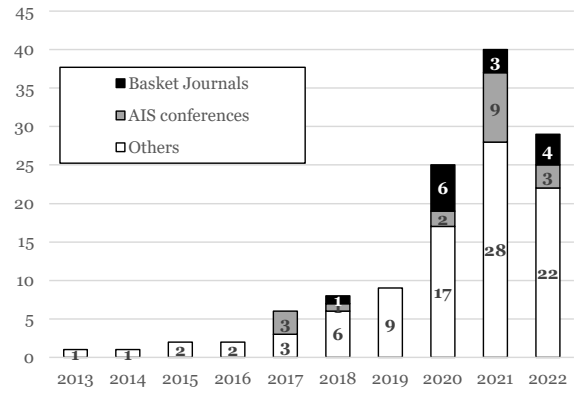

Figure 3. Research Coverage in Algorithmic Management Over Time

Figure 4 combines the two main aspects of our research. The left table displays the extent to which the different research streams in AM are covered in the literature. The right table shows the extent to which the SPICES management functions performed by algorithms are covered in both the entire literature as well as in the literature that only addresses automation. Although the functions are ordered as SPICES, we will present them according to their frequency of occurrence in the literature. With respect to the research areas, the literature primarily focused on the automation of management (53.3%) and algoactivism (40.6%). Specifically, while 19.5% of articles discuss the configuration of AM systems, the informating of management by AM systems (7.5%) lacks coverage. Traditional management (8.3%) and feedback (1.5%) do not receive much attention in AM research.

Perspective	Occurence in literature*
Automate	53.3%
Algoactivism	40.6%
Configuration	19.5%
trad. Management	8.3%
Informate	7.5%
Feedback	1.5%

Management functions	Occurence in literature*	Occurence in „Automate" literature**
Supervising	45.8%	61,9%
Investigating	37.5%	42,2%
Planning	27.8%	30,1%
Evaluating	21.0%	21,1%
Staffing	18.8%	16,9%
Coordinating	8.3%	5,6%

*n=133 **n=71

Figure 4. Research Coverage in the Literature of AM

Automate. Automated and AI contexts denote environments where information gathering and decision-making are performed by algorithms and AI (Holmström & Hällgren, 2021). When deployed on platforms, algorithms coordinate and control resources (Möhlmann et al., 2021). While some human engagement remains, the work process is delimited into self-contained tasks that are managed and surveilled by an automated system. Algorithms use behavioral or geographical data to measure performed work output (Cram & Wiener, 2020; Galiere, 2020), which must be validated to facilitate monitoring by the algorithm (Holmström & Hällgren, 2021). At Uber, for example, algorithms perform the customer-driver assignment and the route planning, while human drivers accept rides and drive customers. Yet, there is little transparency on the rationale behind the assignment. However, driver rating and surge pricing play a

significant role in the allocation and driver performance monitoring (Holmström & Hällgren, 2021; Lee et al., 2015; Möhlmann et al., 2021; Rani & Furrer, 2021; Sivarajan, Varma, & Reshmi, 2021).

Algoactivism. In response to the automation of managerial work, workers derive coping strategies or develop workarounds. These individual and collective practices are subsumed under the term algoactivism (Cram & Wiener, 2020; Lee et al., 2015). Workers try to make sense of algorithmic decisions, and if they are perceived unfair or opaque, workers might resist (Pregenzer et al., 2021). Resistance can be emotional or lead to actions (Heinrich, Vu and Vysochyna (2022). Some articles take a more action-centric perspective that evaluates how algorithmic control is perceived (Alizadeh et al., 2023), how it affects workers' behavior (Cram et al., 2022; Kang et al., 2020; Lee, 2018), how they utilize AM for their work (Jabagi et al., 2021; Möhlmann, Salge, & Marabelli, 2023), or how they circumvent and manipulate algorithms for their own advantage (Elbanna & Idowu, 2022; Jarrahi et al., 2021; Lee et al., 2015; Wood et al., 2019). For example, workers have hired bots to increase their profile ranking or contact employers outside the platform to circumvent fees (Elbanna & Idowu, 2022). By studying an online forum, Jiang, Adam and Benlian (2021) derive eleven algoactivism practices in ridesharing that range from individual "resistance to collective actions" (Jiang, Adam, & Benlian, 2021, p. 12). While individual reactions lead to work-related practices (Bucher, Schou, & Waldkirch, 2021), collective reactions require organization and communication (Cini, 2023; Liu & Friedman, 2021). So far, workers have been privately exchanging in person (Brinkmann, Heiland, & Seeliger, 2022) or online forums (Jiang, Adam, & Benlian, 2021). This will likely change soon, as an EU directive that obligates platforms to ensure that workers can contact each other and their superiors through the platform is currently discussed (Collins & Atkinson, 2023).

Configuration. Configuration refers to the implementation of technical infrastructure and the specification or adjustment of algorithms such that they can act as managers (Jarrahi et al., 2021). In the early phases of Ubers' market entry to new cities, local managers handle the configuration of algorithms (Möhlmann et al., 2021; Parth & Bathini, 2021). During this phase, Uber operates in a hub-and-spoke model. Until sufficient market data is collected, and the headquarters take over control, the regional manager experiments with parameters to adjust them to the local market (Parth & Bathini, 2021). Because managers configure business-critical algorithms, they need to thoroughly understand the technology they use (Giermindl et al., 2022). For this reason, some studies propose the positions of "algorithmists" (Gal, Jensen, & Stein, 2017, p. 7) and "algorithmic occupations" (Kellogg, Valentine, & Christin, 2020, p. 388), who translate, mediate, and manage algorithms. This research stream also includes discussions on the accountability for algorithmic decisions (Gal, Jensen, & Stein, 2017). The configuration must thus allow management to evaluate the algorithm's decision quality (Gal, Jensen, & Stein, 2020). Conversely, managers might suffer from an overreliance on algorithmic decisions (Giermindl et al., 2022; Keding & Meissner, 2021).

Informate. Articles in this category discuss how algorithms inform management about worker behavior and work performance (Cram & Wiener, 2020). Holmström and Hällgren (2021) distinguish organizational contexts as opaque AI contexts when there is low transparency regarding AI decisions. In contrast, augmented AI contexts are high in transparency. Transparency refers to the overall understanding of the algorithms' rationale. In opaque AI contexts, managers decide based on the algorithms' output without understanding the AI's decision-making process (Holmström & Hällgren, 2021). For example, this was observed in a factory, where AI was fundamentally involved in production planning and had a negative impact on factory workers. Management was, however, incapable of assessing the system's detrimental influence because of the lack of understanding (Briône, 2017; Giermindl et al., 2022). In augmented AI contexts, however, the technology improves human involvement because it transparently provides information and rationales for informed decision-making. Management understands the algorithms that support its decision-making to perform the classical management functions (Holmström & Hällgren, 2021).

Management and Feedback. Logically, the reviewed literature rarely treated management actions in the classical sense (Cram & Wiener, 2020) and workers' reactions to classical management (8.3% and 1.5%, respectively). Chalykoff and Kochan (1989) have discussed AM-informed management and worker feedback to this management. Lee (2018) compares workers' reactions to AM decisions with reactions to human management decisions (Lee, 2018). Some articles discuss the tension between existing management and AM. In one case, employees are caught in opposing directives from human management and AM. Sales agents are algorithmically given choices for customer product offers by the software. But, because of sales targets, management instructs agents to ignore the software when their judgment is more accurate (Bader

& Kaiser, 2019). Similarly, human managers adjusted workers' priorities and work practices when the automated work assignment system did not perform as anticipated (Lammi, 2021). Thus, in these cases, tensions occur because human management believes that they can coach workers to perform better (Cram & Wiener, 2020).

What Managerial Functions Do Algorithms Perform?

It became apparent from our first analysis that the automation of managerial work is predominant in the literature on AM. Therefore, we wanted to further understand the type of work that is automated. So far, the focus of AM studies has mainly been on how technology exerts control on workers (Kellogg, Valentine, & Christin, 2020). In contrast, we use established management literature to analyze the functions that algorithms carry out (Tsoukas, 1994). In particular, we employ the SPICES management functions proposed by Carroll and Gillen (1987) to analyze the different functions algorithms perform.

Our analysis shows that algorithms primarily supervise (45.8%) and investigate (37.5%) human workers, which is in line with observations of traditional managers who spend most of their time supervising (Mahoney, Jerdee, & Carroll, 1965). Further, the observed functions of planning (27.8%), evaluating (21.0%), and staffing (18.8%) are less frequent. The coordination function is least discussed (8.3%).

Supervising. In human management, supervising involves direct feedback (Lamond, 2004), whereas in AM, supervising translates into automated nudges or gamification (Huang, 2023). Algorithms incentivize workers to work longer hours (Cram et al., 2020; Griesbach et al., 2019; Tarafdar, Page, & Marabelli, 2022) and ensure that workers keep a constant performance level (Kellogg, Valentine, & Christin, 2020). Service quality and performance are developed through training (Keegan & Meijerink, 2023). In onboarding, algorithms assign training videos that explain standards and rules on the platform (Huang, 2022), while other platforms have tests to confirm existing skills (Weber, Remus, & Pregenzer, 2022). Uber, for example, provides training to improve current job performance (Keegan & Meijerink, 2023).

Supervising also involves allocating resources and assigning tasks to workers (Carroll & Gillen, 1987; de Oliveira et al., 2015). Because their decision-making is automated (Schulze et al., 2022), algorithms can handle more workers with less hierarchical structures than a human manager could (Möhlmann et al., 2021). Algorithms advise workers on what to do and when to do it (Giermindl et al., 2022) and assign tasks based on performance metrics collected through apps (Galiere, 2020; Holmström & Hällgren, 2021). They primarily provide workers with information and guidance to do their job in the best (Cram & Wiener, 2020) and most efficient way (Kang et al., 2020). The provision of task related information is particularly valuable for workers and influences their decision to remain on a platform (Göttel, 2021). As an example, algorithms guide delivery drivers to locations that yield more delivery requests during working hours (Li, 2022). However, due to the auto-acceptance functions, which automatically accept orders for the drivers, they often cannot choose their next delivery (Veen, Barratt, & Goods, 2020).

To make decisions about worker performance, AM relies on pre-defined key performance indicators (KPI) (Galiere, 2020). When these KPIs drop below a certain threshold, the algorithmic decision to discipline workers is triggered (Möhlmann et al., 2021). Algorithms discipline workers by applying sanctions (Jarrahi et al., 2021; Welcman & Zalmanson, 2021), such as banning or temporarily suspending workers from the platform (Möhlmann & Zalmanson, 2017; Möhlmann, Salge, & Marabelli, 2023). Besides suspending accounts, platforms also sanction workers by not assigning them work or reducing payments (Rosenblat & Stark, 2016; Wood et al., 2019). Workers often accept sanctions due to the lack of alternatives. They do not only suffer from the sanction itself, but from the lack of transparency of how these decisions are derived (Möhlmann et al., 2021). Further, digitally captured data can differ from real-world observations, and the algorithmic decisions based on data collected through the respective app might not always be correct. In turn, this affects the correctness of sanctions (Pregenzer, Remus, & Wiener, 2021) and their comprehensibility for workers (Tarafdar, Page, & Marabelli, 2022).

Investigating. In traditional management, managers gather information on operations and events (de Oliveira et al., 2015) to evaluate worker performance. In AM, this information is collected automatically (Möhlmann et al., 2021) and consolidated into KPIs that reflect work performance (Veen, Barratt, & Goods, 2020).

Work-related data differs to a considerable extent depending on the type of workers under algorithm supervision. For knowledge workers, performance is less tangible, which rather makes them subject to job

analysis than output measurement. For job analysis, algorithms collect data from different activities, such as information from E-mail traffic, customer request answering time, time spent in meetings (Giermindl et al., 2022), phone messages, and social media activity (Gal, Jensen, & Stein, 2017), screenshots of monitors and webcams (Jarrahi & Sutherland, 2019; Wood et al., 2019) or keystrokes (Waldkirch et al., 2021). In contrast, "blue collar" workers usually have a more tangible work output. Thus, algorithms use KPIs to quantify worker productivity: work rate and attendance (Galiere, 2020), the number of shifts and fulfilled orders (Heiland, 2022), distance traveled and time taken for a task (Tarafdar, Page, & Marabelli, 2022), acceptance rate and time, travel time (Veen, Barratt, & Goods, 2020), percentage of on-time delivery and delays (Zheng & Wu, 2022). In the future, the comprehensibility of such KPIs will become more critical because the EU will force companies to notify workers about monitoring and decision-making based on this data (Collins & Atkinson, 2023).

Planning. When planning, managers draw on forecasts and act, if needed, to maintain a certain service level (Carroll & Gillen, 1987; de Oliveira et al., 2015). Algorithms maintain the service level by either automatically scheduling shifts and assigning tasks according to prior workload and anticipated customer demand (Heiland, 2022) or limiting the amount of work a worker can sign up for (Bucher, Schou, & Waldkirch, 2021; Weber, Remus, & Pregenzer, 2022). AM manages the workforce by setting financially rewarded goals (Tarafdar, Page, & Marabelli, 2022) or imposing a given work quality (Griesbach et al., 2019). For example, platforms promise workers a guaranteed number of deliveries, which translate into higher earnings (Veen, Barratt, & Goods, 2020). In other cases, platform algorithms rank workers by KPIs (Stewart & Mousavi Baygi, 2021) to account for individual performance and assign shifts based on this ranking (Heiland, 2022; Huang, 2022). However, workers put less trust in shifts scheduled by the algorithm because they perceive them as being less fair than their human counterparts. Workers believe that algorithms are not able to capture nuanced and less tangible information, such as individual differences in travel distance to work or parenthood (Lee, 2018).

Digital labor platforms employ systems that automate time tracking, invoicing, and taxation to support workers (Jarrahi et al., 2021). It allows workers to operate entirely based on the guidance of the AM system, enhanced by guidelines, notifications, and suggestions. The pre-defined work process allows them to work without having to plan out their subsequent actions (Kang et al., 2020). One software, for example, optimizes the daily workflow for office workers (Giermindl et al., 2022) along the entire value chain (Gal, Jensen, & Stein, 2017). However, when the system is not reliable, workers ignore suboptimal instructions (Tarafdar, Page, & Marabelli, 2022) and plan their work independently (Zheng & Wu, 2022).

Evaluating. Managers evaluate workers after investigating their actions, and they express this evaluation through judgment and appraisal of subordinates (Mahoney, Jerdee, & Carroll, 1965). In this management function, quantifiable worker data (Jabagi, Croteau, & Audebrand, 2020) is evaluated and used to control workers, significantly influencing their behavior (Chalykoff & Kochan, 1989; Möhlmann et al., 2021). The results of the evaluation are expressed through rewards and badges (Pregenzer, Remus, & Wiener, 2021). While human managers find quantified automated evaluation advantageous (Chalykoff & Kochan, 1989), it creates distance between managers and workers, as the latter may no longer understand the algorithm's logic (Kellogg, Valentine, & Christin, 2020). Besides worker behavior, the algorithm also evaluates the quality of work. Workers on online platforms are thus subject to algorithmic condition checks. In particular, Uber demands that drivers and their vehicles fulfill company standards and legal requirements that do not refer to their work performance (Cram et al., 2020).

Staffing. Managers must recruit, place and promote employees to maintain an effective workforce (Mahoney, Jerdee, & Carroll, 1965). In addition, AM platforms must balance the supply and demand of work. While the aim is to have an immaculate service level, employing too many workers would impede their earning possibilities and have them switch to other sources of income (Möhlmann et al., 2021). Recruiting employees through AM requires reliable identity and certificate checks that must be performed in cooperation with government entities (Heiland, 2022; Huang, 2022). For this purpose, platforms employ gatekeeping mechanisms, that is, a thorough selection process and waiting lists (Veen, Barratt, & Goods, 2020) to select their workforce (Griesbach et al., 2019; Wiener, Cram, & Benlian, 2021). Some platforms employ a core workforce assigned into shifts to ensure a steady service level (Li, 2022). To keep fluctuations low and enhance long-term motivation, Cram et al. (2022) suggest awarding badges and financial payments to workers. For instance, platforms use performance metrics to promote employees to higher ranks (Huang, 2022) and award them badges to acknowledge high performance. Higher ranking and awards mostly

translate into higher paying jobs (Stewart & Mousavi Baygi, 2021). In general, financial contributions to insurance or retirement are found to have a positive impact on the loyalty of workers toward a platform (Hong et al., 2020).

Coordinating. Coordination aims to create the foundation for harmonious interaction within an organization (Fayol, 1949). In the light of AM, coordination needs to be better understood (Bouty & Drucker-Godard, 2019). Information sharing is a fundamental aspect of coordination (Mahoney, Jerdee, & Carroll, 1965). Management is responsible for establishing the required infrastructure (Bouty & Drucker-Godard, 2019) and thus must build coordination structures to involve workers (Liu & Friedman, 2021). While employees still require (human) support, communication between managers and workers has transformed into automated responses to workers in many cases (Möhlmann & Zalmanson, 2017). One example is an AM system that integrates information exchange between workers and human managers via WeChat (Jabagi, Croteau, & Audebrand, 2020; Li, 2022). In atomized job settings, cooperation between workers is not necessary. However, workers have created virtual and physical spaces to discuss their experience and success on the platform through chatgroups, forums, and associations (Cini, 2023; Curchod et al., 2020; Waldkirch et al., 2021). Brinkmann, Heiland and Seeliger (2022) report that 61% of food delivery drivers have at least frequent contact with other riders outside the application (Brinkmann, Heiland, & Seeliger, 2022). The need for communication and coordination appears so fundamental for workers that EU legislation will enforce platforms to enable horizontal and vertical communication of workers (Collins & Atkinson, 2023).

Discussion

This section outlines the implications of our work, addresses the limitations of our review, and, finally, discusses avenues for future research on AM.

Implications

In this paper, we conducted a structured literature review (vom Brocke et al., 2009) to examine the state of the art in research on AM. Our review contributes to the body of knowledge by adopting a new perspective on AM. Specifically, we extended Benlian et al.'s (2022) framework and analyzed the literature according to the six research streams on AM, as presented in Figure 4. To unfold the predominant focus of the literature on management automation, we used the six management functions of Carroll and Gillen (1987) to understand what type of managerial work is already performed by algorithms.

Our findings show that research has focused on the interaction of algorithms and workers, emphasizing *automation* through and *algoactivism* toward AM. On platforms, automation increases productivity and allows handling a larger workforce by clearly structuring processes to supervise atomic tasks (Holmström & Hällgren, 2021; Lee et al., 2015; Möhlmann et al., 2021). Articles also examined how workers interact with and react to algorithms (Cram & Wiener, 2020; Lee, 2018). More specifically, research either investigates how algorithms and workers collaborate (Giermindl et al., 2022; Möhlmann, Salge, & Marabelli, 2023; Wiener, Cram, & Benlian, 2021) or how AM systems exploit workers leading to algoactivism (Elbanna & Idowu, 2022; Möhlmann, Salge, & Marabelli, 2023; Wiener, Cram, & Benlian, 2021). Our literature review also has shown that how managers configure and receive information from AM systems is currently insufficiently understood. While algorithms inform managerial decision-making (Zheng & Wu, 2022), they are often opaque (Holmström & Hällgren, 2021), and managers struggle to comprehend their logic (Giermindl et al., 2022).

When concentrating our review on the different management functions, we found that supervising and investigating are the most frequently performed functions in AM. AM systems supervise workers by assigning tasks (Giermindl et al., 2022), incentivizing them to work more (Cram & Wiener, 2020; Griesbach et al., 2019; Tarafdar, Page, & Marabelli, 2022), and sanctioning them when they underperform (Wood et al., 2019). When investigating, AM systems collect data to analyze work (Gal, Jensen, & Stein, 2017; Giermindl et al., 2022; Waldkirch et al., 2021) or measure output (Tarafdar, Page, & Marabelli, 2022; Veen, Barratt, & Goods, 2020; Zheng & Wu, 2022) based on KPIs (Cram & Wiener, 2020; Giermindl et al., 2022). AM systems go so far as disciplining workers when they behave undesirably by reducing payments (Wood et al., 2019) or excluding them from the platform (Galiere, 2020; Möhlmann & Zalmanson, 2017; Möhlmann et al., 2021). We further found that most articles discuss the assignment and supervision of

individually performed atomic tasks, for example, on Amazon MTurk or Uber (Bergvall-Kåreborn & Howcroft, 2014). However, AM does not yet manage more complex tasks where the contributions of several individuals need to be coordinated.

Limitations

This work has several limitations. Despite the fact that our search strategy was aimed at including as many relevant articles as possible, we cannot completely rule out the possibility that we missed potentially relevant papers. First, our keyword choice influenced the number of search hits. We mitigated a potential bias in keyword selection by testing different keyword combinations and by performing forward and backward search. Second, from our 688 search hits, we could not access 17 papers due to the subscription policy of our institution. Third, the specification of our inclusion and exclusion criteria influenced the final set of articles that we analyzed. We deem the choice of our inclusion and exclusion criteria appropriate, given the focus of our review and the research standards of our field (e.g., we only considered articles that are written in English and that have undergone peer review).

For our analysis addressing which managerial functions are performed by algorithms, we drew on the SPICES framework by Carroll and Gillen (1987) that goes back to the work of the French entrepreneur and scholar Henry Fayol (1949). Our results would have been different if we had applied another management framework, such as Mintzberg's (1973) descriptions of managerial roles. In fact, in the management literature, there has been a long debate on whether Fayol's functions or Mintzberg's roles (1973) better capture the work that managers perform (Lamond, 2004). Many management scholars agree that Mintzberg's (1973) work on managerial roles lacks an empirical basis, and it has been criticized as not being related to organizational performance (Carroll & Gillen, 1987). Especially since we were interested in the actual work that managers perform, we believe that the SPICES framework (Carroll & Gillen, 1987) that builds on Fayol's (1949) functions is the most suitable choice.

Avenues for Future Research

Our work on the state of research and management functions in AM may inform future studies. We propose a framework that organizes future research avenues for AM along the systems lifecycle phases 1) design and implementation, 2) configuration, and 3) use. We further differentiate the technological, managerial and organizational perspectives in each phase, as displayed in Figure 5. Within each intersection of phase and perspective, we define distinct research topics for which we propose an illustrative research question. In the following, we outline these topics phase by phase.

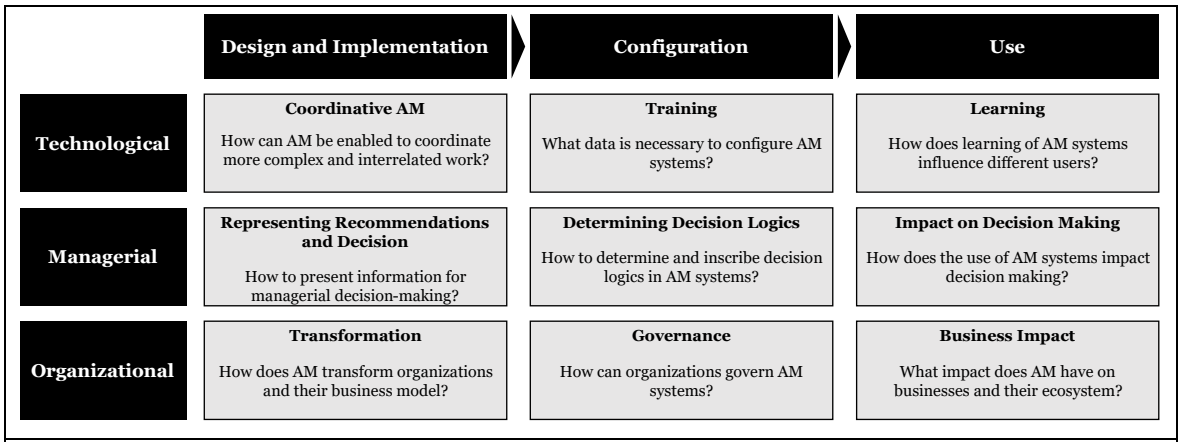

Figure 5. Topics in Future Research

First, further research is needed to understand the *design and implementation* of AM systems. The frontiers of AI constantly progress in terms of scope and performance (Berente et al., 2021). One *technological* frontier of AM is the scope of capabilities along the managerial function of coordination. Currently, AM largely manages atomized tasks and individual workers (Brinkmann, Heiland, & Seeliger, 2022). Platforms use detailed performance and behavioral data on these tasks to exert control, nudge

workers towards certain actions, and even exclude them from the platform (Altenried, 2020; Galiere, 2020). Because digital technology enables many elements of Taylorism, such as the surveillance and control of labor (Altenried, 2020; Rosenblat & Stark, 2016; Wood et al., 2019), many scholars argue that AM is a new form of (digital) Taylorism (Altenried, 2020; Liu & Friedman, 2021). While this calls us to question the fairness of AM (Schulze et al., 2022), it also highlights that AM is currently not able to coordinate multiple workers to support them in working together to create more sophisticated products or services (Bouty & Drucker-Godard, 2019). From a technological perspective, we thus argue that AM needs to be developed along the managerial function of coordination. We refer to this as *Coordinative AM*. In contrast to current AM, Coordinative AM will support workers not by dividing them but by steering the interaction and work among them toward a collectively beneficial outcome. From the *managerial perspective*, there remain obstacles in how to *present recommendations* to support managerial decision making and represent the rationale for decisions taken by AM systems. Studies show that managers do not sufficiently question algorithmic decisions as much as their own (Gal, Jensen, & Stein, 2020). Gal, Jensen and Stein (2020) suggest to therefore "design for ambiguity, not certainty" as a starting point. Research should thus study managers' perceptions and reliance on AM systems to uncover potential biases and sensitize managers toward their inherent ambiguity. Lastly, there remain research opportunities in AI-driven digital *transformation* in companies (Jarrahi, Möhlmann, & Lee, 2023). How do *organizations* transform and change their business model as a response to implementing AM? IKEA, for example, outsourced its assembly service for furniture to TaskRabbit, an AM platform for handyperson services. Research should, therefore, work to understand how traditional organizations (Lippert, Kirchner, & Wiener, 2023; Parent-Rocheleau & Parker, 2022) transform their business when they shift business competencies and management functions to AM systems.

Second, further research is required to understand the *configuration* of AM systems. From a *technological* point of view, detailed insights regarding the underlying data, technology stack and the *training* of AM algorithms are missing. With the increasing datafication of organizations (Leonardi & Treem, 2020), required data for AM is becoming available in traditional organizations. It has been argued that digital twins allow the datafication of diverse resources and, as such, could be an enabler for AM in traditional work contexts (Wurm et al., 2023). We thus encourage researchers to investigate what data is collected and how it is used to train AM systems in specific organizational contexts. From a *managerial perspective*, we need to understand how managers *determine and inscribe decision logics* into AM systems and what data they supply for training self-learning algorithms. In our study, we identified that the modifiability of AM systems is a fundamental research topic in this regard. Closely tied to this is the question how organizations set up *governance* structures for AM. Governance structures specify for which managerial tasks and under which conditions AM systems are used and how they are evaluated. For example, when Uber enters a new city, the local office experiments with model parameters considering the local market and its unique features (Parth & Bathini, 2021). As more data becomes available, AM becomes more autonomous, and the headquarters take over control (Möhlmann et al., 2021; Parth & Bathini, 2021). How do organizations make this transition from market entry to automated decisions? How do they evaluate the performance of AM systems versus human managers? Future research should address these and related questions.

Finally, we urge research to shed light on the *use* of AM systems. We have not yet fully understood the impact *technology* that nudges, controls, and disciplines (Altenried, 2020; Galiere, 2020) has on workers. Platform workers, for instance, are both controlled (Kellogg, Valentine, & Christin, 2020) and supported (Jabagi et al., 2021) by ever *learning* AM systems. However, there are still conflicting views in research about the exploitation and empowerment of workers (Jabagi et al., 2021) and the effects of the learning algorithms. Research should, therefore, focus on understanding how AM systems can guide workers in carrying out their tasks more effectively by using the learning algorithms that control workers and providing data that supports workers. From a *managerial perspective*, it remains unclear how AM helps managers make better *decisions* or ultimately substitutes their decisions. While it seems likely that certain management functions will be (almost) entirely performed by algorithms, others will remain in the dominion of humans, while most tasks will be shared by humans and AM (Jarrahi, Möhlmann, & Lee, 2023). On this spectrum of AM autonomy, research must understand the impact on decision making by comparing the performance in both qualitative and quantitative regards. Research should evaluate how to best use AM systems in both objective and subjective managerial scenarios (Lee, 2018). From the *organizational perspective*, the impact of AM systems on businesses and ecosystems must be understood.

Besides measuring the system's decision performance, researchers must investigate how AM systems impact value creation on an organizational level.

Conclusion

In this paper, we presented a systematic literature review on AM. Drawing on two existing frameworks, we categorized and analyzed 133 papers to assess the state of the art and point to new research avenues. Our key findings are twofold. First, we found that the major share of research on AM addresses the automation of managerial work. Second, the automation of managerial work mainly focuses on supervising and investigating employees' work. Based on our analysis, we provide a framework with topics and exemplary research questions for future research on AM.

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