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Completed Research Paper

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Abstract

We review the literature on algorithmic management to help future researchers acquire a comprehensive "recap" of past research with detailed discussions on the main findings and develop a taxonomy as a tool of summarization that assists researchers in reflecting critically on their systems and identifying potential gaps. We determine five critical areas of algorithmic management: the mechanisms of algorithmic management, effects of algorithmic management, second party's response to algorithmic management, concerns around algorithmic management, design of algorithmic management, and policy implications. These topics are analyzed and discussed.

Keywords: Algorithmic Management, Literature Review, Taxonomy

Introduction

Algorithmic management is no longer a fictional concept but a part of our reality. It challenges existing business models and reshapes current organizational control and employment relationships. Amid the rise of the platform economy, the use of algorithms has increasingly drawn the public and scientists' attention. Jabagi *et al.* (2020) described the gig economy as "an emerging labor market in which organizations engage independent workers to complete short-term contracts known as "gigs", by connecting workers to customers via a platform-enabled digital marketplace". These platforms function on the ground of automated decision-making systems that rely on prolific data collection and complex algorithms, which allows them to remotely direct, evaluate and discipline the gig workforce without the need for the intervention of human managers (Wood, 2021). Algorithms affect workers' schedules and the number of orders they receive, and they can assign "nudges" and autonomously impose punishments (Griesbach *et al.*, 2019; Wood *et al.*

2019; Lee *et al.*, 2015). Within Uber ride-hailing platforms, for instance, drivers are automatically matched with passengers in the closest proximity and then instructed to follow an "efficient route" suggested by the application. In addition to the gig economy, algorithmic management is increasingly deployed in conventional working settings.

However, due to the opaque nature of algorithms, many papers raise concerns over the ambiguity and biases of this system. Furthermore, the intervention of human managers to remedy the unfairness is also limited to the degree of automation of the algorithmic management system (Wood, 2021). Besides, algorithmic features are reported to intensify work effort, favor constant surveillance, and minimize gaps in workflow,

causing anxiety and insecurity to gig workers (Wood, 2021). During our review, we noticed that most papers using the term algorithmic management are dedicated to the issues around the platform economy. In contrast, algorithmic control is primarily used in papers related to the conventional economy or technical/programming issues. However, there is neither a clear definition nor an explanation of the difference. Therefore, we regard these terms as interchangeable and decided to use *algorithmic management* in our study.

Algorithmic management has become more commonplace in many businesses and thus has grown to be an important topic in information system research. However, there is a lack of comprehensive and structural tools to view this system from other perspectives and work contexts other than platform settings. Hence, our motivation is to generate a holistic summary of the knowledge available about algorithmic management for the sake of a broader picture and a valuable foundation for future work. Our research goals are to provide an extensive literature review on the critical areas of algorithmic management in both platform and traditional work contexts. We summarize our findings by developing a taxonomy that structures the previous knowledge with distinguishing power.

In order to achieve our goals, we organized the paper as follows: Section 2 consists of two subsections. The first subsection includes a detailed description of the literature search and selection processes, while the second one provides the results of our literature analysis. Section 3 is dedicated to the description of the taxonomy development stages. In Section 4, we present the results along with a detailed description and explanation of the dimensions and characteristics. Finally, section 5 summarizes the contribution and discusses the limitations of this paper, thereby identifying potential questions for future research.

Literature Review

Methodology

During the preparation process for our research, we were able to study various methodology-related literature (vom Brocke *et al.*, 2009; Kitchenham *et al.*, 2009; Günther *et al.*, 2017).

Phase	Selection criterion	Paper
First phase *(Mass-searching)*	**Databases:** ScienceDirect, IEEE, AISeL, Mendeley, Willey Online Library **Keywords:** "algorithmic", "algorithmic control", "algorithmic management", "automated decision-making", "gig economy", "platform work", "platform economy", "digital work platform", "online platform", "platform-based gig work", "workforce management", "workforce control", "automated nudges", "sharing economy", "app work", "microwork". **Conditional keyword:** "algorithmic" **Exclude:** unreliable sources of information (blogs, overviews, newspapers, workshops, abstract-only, etc.)	320
Second phase *(Filtering)*	**Include:** • Papers with titles, abstracts, and keywords relevant to the algorithmic management topic **Exclude:** • Duplicates	91
Third phase *(Deep reading)*	**Include:** • Papers that address algorithmic management as its central topic • Papers where algorithmic management plays a substantial role in addressing the central topic **Exclude:** • Methodological/ technical papers	55

Phase	Selection criterion	Paper
Table 1. Search Process		

Following Heinrich *et al.* (2020), we use the framework proposed by Webster and Watson (2002) as a base for our literature review. We focus on various issues related to algorithmic management concepts to give a broad overview of the related literature. Our review consists of the search and selection processes and the analysis of the investigated literature.

We began our research by selecting the databases for the literature search and decided to use three popular databases covering various fields. Furthermore, only articles available from 2012 up until 2022 were considered. Details on the search parameters and the process are given in Table 1.

Out of 320 potential candidates obtained through mass-searching, we removed 229 papers, resulting in 91 papers being left after removing duplicates and only considering papers that dealt with algorithmic management specifically. From these 91 papers, we further removed an additional 36 that did not provide diverse aspects associated with algorithmic management since they did not deal with algorithmic management as a central topic. As a result, our final database consists of 55 papers.

Out of those 55 papers, 49 were research papers, two pieces of research "in-progress", two conferences, one technical report, and one review article. In addition, we discovered that out of 55 papers, 75% were published by journals, while the rest was presented during conferences.

Results

Despite the long-lasting researchers' interest in applying algorithms in different sectors, we could not find a consensus on the algorithmic management definition. According to Lee *et al.* (2015), algorithmic management refers to "software algorithms that assume managerial functions and surrounding institutional devices that support algorithms in practice". Pregenzer *et al.* (2021) and Adensamer *et al.* (2021) use the term - algorithmic control – to describe the ability of digital technology and algorithms to guide and control workers in a manner previously performed by human managers. As mentioned before, we regard these terms as interchangeable. Besides, Langer and Landers (2021) proposed objective definitions for the groups that directly or indirectly interact with algorithmic management. First, parties are the stakeholders with at least some direct control over whether and to what degree an artificial system will alter their decisions. Second, parties are the stakeholders who are "directly affected and targeted" by algorithmic management; third parties are those who observe algorithmic management's decisions, not directly affected by them (Langer and Landers, 2021).

It has been shown that algorithmic management systems are most prevalent in the gig economy, performing managerial functions, such as matching workers with clients, tasks assignment, and workers' performance evaluation along with potential punishment or rewards (Cheng and Foley, 2019; Lee *et al.*, 2015; Basukie *et al.*, 2020). App-work, e.g., Uber, crowd-work platforms, e.g., Upwork, capital platform work, e.g., Airbnb, and e-commerce platforms, e.g., eBay, are among the most prominent examples of systems with significant dependence on algorithmic management. However, there are cases of using algorithmic management outside the platform space. Bigman *et al.* (2021), for instance, discussed the application of algorithmic decision-making (ADM) that is associated with algorithmic management in the medical sector. The authors mentioned that individual decisions related to treating patients could be shifted to algorithms, in particular, to avoid bias and unfair decisions on the part of human doctors (Bigman *et al.*, 2021). Algorithmic management is also being used in the public sector by allocating police staff to crime scenes (Nagtegaal, 2020). Thanks to the deep reading phase, we could highlight the most investigated debates around algorithmic management.

The types of algorithms are crucial bases for understanding algorithmic decision-making mechanisms. Parent-Rochelau and Parker (2021) distinguished algorithms according to their functions and mentioned three types, descriptive, predictive, and prescriptive. "Descriptive algorithms are used to record the past events and analyze their influence on the present events" (Leicht-Deobald *et al.*, cited in Parent-Rocheleau and Parker, 2021). The focus of the predictive algorithms belongs to the future events and their likelihood

to occur (Cheng and Hackett, cited in Parent-Rocheleau and Parker, 2021), while the prescriptive algorithms can identify the best possible solution and either recommend it or directly implement it (Cheng and Hackett, cited in Parent-Rocheleau and Parker, 2021; Leicht-Deobald *et al.*, cited in Parent-Rocheleau and Parker, 2021). Moreover, many authors intended to classify algorithms according to their degree of automation. According to the obtained literature, there is a system-level bureaucracy (fully-automated), a screen-level bureaucracy (semi-automated), and a street-level bureaucracy when the technology can be potentially used as a support tool (Nagtegaal, 2020; Martin, 2019). The use of algorithms in automated decision-making is vital for platform-mediated works due to the real-time demand matching mechanism and the need to manage a multiplicity of parties.

Rating, online review, and behavioral nudges are signatures and integral parts of algorithmic management. Rating systems have been "utilized in marketplaces to indicate the performance level of the producers in the sharing economy" (Basukie *et al.*, 2020). The evaluation of the Uber drivers' performance, for example, depends on the passengers' ratings after each ride and the level of cooperation of the driver with algorithmic assignment" (Lee *et al.*, 2015; Cran *et al.*, 2020). Based on the obtained ratings, algorithmic management either rewards the worker or conducts behavioral nudging (Lee *et al.*, 2015). Thalers and Sunstein define a "nudge" as "any aspect of the choice architecture that predictably alters people's behavior without forbidding any options or significantly changing their economic incentives" (cited in Gal *et al.*, 2020). It is found that workers who happened to decline the assigned tasks at least once or whose rating was lower than a certain level would not be favored for future jobs or even banned from the system for some time (Griesbach *et al.*, 2019; Möhlmann and Zalmanson, 2017; Wood *et al.*, 2018). Since the logic behind such decisions is usually a mystery to the workers, many authors describe algorithmic management as a "black box" (Basukie *et al.*, 2020; Griesbach *et al.*, 2019).

Autonomy, the possibility to be your own boss, the freedom to choose when and how long to work, and as a result, how much to earn, are often regarded as a hook of the gig economy (Griesbach *et al.*, 2019; Wood *et al.*, 2018). However, numerous interviews of the platform workers showed that the reality does not correspond to common beliefs. (Möhlmann and Zalmanson, 2017). Möhlmann and Zalmanson (2017) explain that platform workers often do not identify themselves with the organizations they are working for due to so-called autonomy. Having little contact with either human supervisors or co-workers, they face social isolation (Jabagi *et al.*, 2020). Platform workers use externally created internet forums to compensate for the lack of human communication and share their experiences in interactions with algorithmic management (Chenga and Foley, 2019; Jabagi *et al.*, 2020). Moreover, platform workers are also reported to experience precarious work conditions, with unpredictable earnings, and often feel the pressure to do extra work. Drivers did not feel empowered to "dictate their work hours or circumstance because of uncertainty around how much they would be paid" (Page *et al.*, 2017)

Hand in hand with the studies of the effects of algorithmic decisions is the scholar's interest in how workers react to them. Such responses can be classified into two types: emotional or actional (Langer and Landers, 2021; Pregenzer *et al.*, 2021). Regarding emotional responses, perceptions and attitudes like trustworthiness, perceived fairness, perceived autonomy, and organizational attractiveness appeared more often in the literature (Langer and Landers, 2021; Pregenzer *et al.*, 2021; Jabagi *et al.*, 2020). Möhlmann and Zalmanson (2017) also mention cases of "sensemaking" and "creation of stories and myths" among the workers as reactions to algorithmic management. Other common reactions are blending, bridging, distancing, and separating (Pregenzer *et al.*, 2021). The first two can be associated with workers' abilities to cooperate with the algorithms, while the last two represent resistant behavior (Pregenzer *et al.*, 2021). Many of the obtained papers described the so-called "gaming the system" (Langer and Landers, 2021; Jabagi *et al.*, 2020; Pregenzer *et al.*, 2021). Authors describe it as the second parties' behavior oriented toward finding the "loopholes in the system" for their benefit (Möhlmann and Zalmanson, 2017).

The implementation of algorithmic management also raises some concerns, namely, information asymmetry, low level of transparency, biases, and the responsibilities of stakeholders regarding algorithmic decisions (Möhlmann and Zalmanson, 2017; Langer and Landers, 2021; Parent-Rochelau and Parker; 2021; Gal *et al.*, 2020). First, information asymmetry is reported dominantly in ride-hailing platforms. The platform withholds vital information about the ride request before drivers make the decision to accept or reject it (Basukie *et al.*, 2020). Such tactics of algorithmic management trigger resisting reactions of the second parties and often result in the intention to game the system (Möhlmann and Zalmanson, 2017). Second, scholars voice concerns over the opacity of algorithmic decisions. The algorithmic system can

impose sanctions automatically and seemingly favor one group of workers over another with respect to task allocations, often without a detailed explanation as in traditional feedback practices. Jabagi *et al.* (2020) alert that when algorithms lack transparency, the actions generated by an algorithm can be "impenetrable, erratic, and unpredictable", provoking frustration and leading to reductions in workers' autonomy. Algorithmic opacity reduced second parties' abilities to "socialize into the organization", "to understand the organizational landscape" or "to understand the logic of the decisions made about them and their practices" (Gal *et al.*, 2020).

Third, many scholars also question the fairness of the algorithmic management decisions by discussing the biases and potential discriminations (Rhue, 2019; Baier *et al.*, 2019). According to Nowik (2021), algorithmic management can "lead to wrong decisions, discrimination, and even social exclusion (algorithmic exclusion)". For instance, more experienced workers are more favorable to algorithmic management (Wood *et al.*, 2018; Griesbach *et al.*, 2019). In 2019, Baier *et al.* investigated the challenges around algorithmic management during the three stages: pre-deployment, deployment, and non-technical. According to the authors, biases could be avoided if there is enough data available, the right data of good quality, and constant monitoring. Forth is the responsibility of stakeholders regarding algorithmic decisions. Adensamer *et al.* (2021) mentioned that with the introduction of ADM organizations experienced the "responsibility vacuum". Authors reason it with the creation of the new roles and unclear assignment of the tasks (Adensamer *et al.*, 2021). In 2021, Nowik mentioned that "algorithmic management can cause a power imbalance that can be difficult to challenge without knowledge of how these systems work and the resources and expertise to assess them properly". Due to the rapid development of the algorithms, they cannot be regarded as a tool but rather a "subjective perception of a new category with its specific characteristics and implications" (Nowik, 2021). Therefore, the author suggests an introduction of a new legal entity, "electronic personhood", so that instead of first or second parties, an algorithm itself could be responsible for its actions (Nowik, 2021).

There is an extensive amount of literature investigating the effects of algorithmic management on human well-being, and the majority of the papers bring attention to the dark side of it (Chenga and Foley, 2019; Gal *et al.*, 2020; Parent-Rocheleau and Parker, 2021). However, the number of papers suggesting policy implementation solutions is far less significant. Nevertheless, we can identify some studies that review current policies and propose directions to remedy the harms of algorithmic working conditions. For example, reframing could provide alternative algorithm implementation or design (Gal *et al.*, 2019). Jabagi *et al.* (2021) introduce the concept of the *perceived algorithmic autonomy support (PAAS)*, and suggest that "the key to ethically unlocking the potential of digital labor platforms lies in promoting workers' autonomy". Moreover, due to the observed behavior and outcomes of the algorithmic management, the presence/possibility of a human intervention stays significantly important (Nowik, 2021; Bigman *et al.*, 2021).

Taxonomy Development

Classification into taxonomies is crucial for many disciplines as it allows researchers to investigate and analyze complex issues (Nickerson *et al.*, 2012). Our taxonomy aims to depict a holistic picture of what topics are being addressed around algorithmic management, facilitating the identification of research gaps. For the sake of the mutual exclusiveness and collective exhaustiveness of taxonomy and algorithmic management, we define a taxonomy object as a single study within an article *found during our literature review*. Thus, the number of objects could be larger than the number of relevant papers found during the literature search.

This section depicts the details of the development method, dimensions, and characteristics of the taxonomy for algorithmic management, which is based on the method provided by Nickerson *et al.* (2012). Following Nickerson *et al.* (2012), we focused on the characteristics of the objects being examined so that our taxonomy approach is also phenetic.

We started by defining our meta-characteristic(-s). Meta-characteristics should base on the taxonomy's target object, target audience, and the use intention of the taxonomy (Nickerson *et al.*, 2012). As mentioned above, our target object is algorithmic management, and the purpose is to depict broad topics around algorithmic management for the researchers to identify research gaps and position their studies on the research map. Therefore, we decided to have a single meta-characteristic - Contemporary discussions around algorithmic management.

For the second step, we decided to start with the empirical-to-conceptual approach due to the limited prior understanding of the domain. Analyzing the literature, we managed to identify several objects dedicated to similar characteristics of algorithmic management. For example, objects obtained from the works of Griesbach *et al.* (2019), Parent-Rocheleau and Parker (2021), and Kellogg *et al.* (2020) allowed us to identify three characteristics of algorithmic management: discipline, evaluation, and direction. Further, three characteristics became a fundament for the "Mechanisms of algorithmic management" dimension.

We continued with the conceptual-to-empirical circle that allowed us to group the remaining objects, those that could not be grouped with each other, and could not provide a base for the further dimensions, logically. As a result, we obtained different characteristics and sub-characteristics for each of the dimensions. During this circle, we reorganized our taxonomy multiple types trying to avoid duplicates or wrongly assigned sub-/characteristics. We also were accurate with the names we gave each of the taxonomy elements, as it was of significant importance to stay objective. We repeated the circles until all assigned objects were mutually exclusive and collectively exhaustive.

Dimension	**Characteristics**			
Mechanisms of AM	Algorithmic matching (2)		Algorithmic controlling (25)	
Effects of AM	Individual-level (29)	Organization-level (13)	Macro-level (3)	
Second party's responses to AM	Perceptions and attitudes (16)		Reactions (19)	
Concerns around AM	Socio-concerns (10)		Design concerns (25)	
Design of AM	Types of algorithms (2)	Degree of automation (1)	Sociomateriality (6)	
Policy implications	Legal enforcement (2)		Alternative suggestions (8)	
Other	Mistakes in ADM (2)	Research opportunities (3)	Platform urbanism (1)	Driven factors for the second party's perception (7)

Table 2. Taxonomy of algorithmic management

After several iterations, we landed on seven dimensions: Algorithmic management design, Mechanisms of algorithmic management, Concerns around algorithmic management, Second party's response to algorithmic management, The effect of algorithmic management on the second and third party, Policy implications, and Other. The dimension Other was included to group objects without a strong connection to any of the six main dimensions, but that could still enrich the taxonomy. At the end of every iteration, subjective and objective ending conditions taken from Nickerson *et al.* (2013) were checked.

We repeated the second and third steps until (1) all 174 objects were assigned, (2) the mutually exclusive and collective exhaustive conditions were satisfied, and (3) further iterations would not lead to any changes in the taxonomy. When all three mentioned conditions were fulfilled, the taxonomy development process ended. A representation of the nine performed iteration circles can be found in the digital supplement[1].

Table 2 represents the final version of the developed taxonomy. The number in brackets represents the number of objects assigned to each characteristic.

[1] https://figshare.com/articles/conference_contribution/supplement_data_lit_review_taxonomy_xlsx/20730400

Dimensions and characteristics

Mechanisms of algorithmic management

The studies of the mechanisms of algorithmic management take place mostly in platform work contexts. Algorithmic management mechanisms are a set of algorithmic designs through which platforms mediate market supply and demand and exert control over the service providers to satisfy the goals of platform owners. In some studies, this theme is also referred to as the roles or the uses of algorithmic management.

Algorithmic matching in platform works is the "algorithmically mediated coordination of interactions between demand and supply" (Möhlmann *et al.*, 2021). Platforms use algorithms to perform the function of a marketplace (Griesbach *et al.*, 2019), making information available on the platforms to facilitate decision-making and recommending the best possible matches that balance the interests of both the provider and the user-customer.

To ensure the quality of a match, the algorithms are fed with input and output data. Besides preliminary inputs (client's requests, time availability, locations, etc.), output data like ratings and online customer evaluation have been reported to create a salient impact on the likelihood of job matches. In the case of ride-hailing, favorable rating scores are manifested in relatively more ride allocations (Möhlmann *et al.*, 2021), while high ranking and positive feedback lead to a higher possibility of being visible on search results to clients in crowd-work platforms (Stark & Pais, 2020).

Algorithmic controlling characteristic is a crucial topic that draws the most attention in scholarly research, which can be noticed by the number of objects sorted into that category. According to Möhlmann *et al.* (2021), algorithmic control is the use of algorithms to supervise workers' performance and ensures it aligns with the organization's goals. Likewise, Tomprou & Lee (2022) define it as the automation of managerial practices, which were traditionally the responsibility of middle or upper management.

The controlling characteristic of algorithmic management is investigated in three predominant research streams. The first study stream attempts to identify the mechanisms through which algorithms perform managerial functions. *Algorithmic direction, evaluation, and discipline* are three widely-acknowledged control mechanisms that are deployed to obtain desired behaviors from the second party. Algorithmic direction is prevalent in ride-hailing and warehousing work contexts, where algorithms are designed to drive the workers to do particular tasks through the automation of task allocation and instruction regarding route and time. Inside Amazon's warehouse, for example, workers are automatically assigned an item with a limited pick rate and an optimal route direction (Wood, 2021). While workers perform their tasks, algorithmic evaluation entailing the use of monitoring and rating features is activated (Kellogg *et al.*, 2020). The first party uses algorithms to track and record workers' performance to ensure the platform rules and standards are followed. Crowd-work platforms like Upwork are reported to utilize a feature named "work diary" to take screenshots of workers' desktops for productivity evaluation regularly. (Waldkirch *et al.*, 2021). Together with data collected from algorithmic surveillance, ratings and rankings serve as performance metrics that are frequently available and visible to the first party and third party. These metrics are important inputs to the discipline mechanism through which algorithms impose sanctions or provide rewards accordingly to the behaviors of the second party. Curchod *et al.* (2020) revealed in their study of eBay's automated practices that the seller's account shall be blocked if the satisfaction level falls below 95 percent. The three mechanisms above are often referred to as formal control in the platform economy.

The second stream of studies is to bring clarity to *behavioral nudging,* which is widely discussed in the gig economy literature. Behavioral nudges refer to the use of insights from behavioral science to subtly act on workers' minds in order to direct their choices towards organizational goals (Möhlmann *et al.*, 2021). Some prominent principles used in ride-hailing works are the goal gradient effect, loss aversion, and default heuristic. Uber, for instance, tends to nudge drivers into continuing driving when they attempt to log off by sending pop-up reminders that they are only a few trips away from the target. However, Bathini & Shalini (2021) emphasize that misleading, non-transparent information, and factual misrepresentations do not constitute a nudge. 'Surge pricing' and 'demand' notifications are two examples. Universally agreed amongst the studies of the gig economy, nudges are an integral part of algorithmic control. While algorithms are the foundation for designing and implementing nudges (through app settings, notifications, and incentive schemes), nudge parameters are collected and then fed back to the algorithms to fine-tune them further. This process constitutes the informal control mechanism of the platform economy.

The last research stream is to *analyze such mechanisms in comparison with other forms of control*. Similar to Taylorism, also known as Scientific Management theory which highlights scientific methods in production management, algorithmic control employs invasive monitoring practices upon worker's performance, triggering different forms of alienation (Duggan *et al.*, 2020; Galière, 2020). However, unlike Taylorism, wherein rules and standards are highly bureaucratic, the rules embedded in algorithmic control show little stability. They are updated frequently and often without formal notice to the second party.

In addition to Taylorism, direct and indirect control are two other forms compared to algorithmic control. Bathini & Shalini (2021) show that algorithmic control is an advanced form of direct control in terms of automation, both in its scale and scope. On the contrary, the difference between indirect and algorithmic control is unclear (Bathini & Shalini, 2021; Mengay, 2020).

Effects of algorithmic management

The study of the effects of algorithmic management is a broad topic that evolves around the current and potential impacts of algorithmic management on work conditions, work organization, and society in general. For the sake of our taxonomy, we classify relevant objects into *individual-level, organizational-level, and macro-level.*

Individual-level effects of algorithmic management encompass discussions around two main topics: the autonomy and welfare of individuals whose work activities are subject to surveillance of algorithms.

Autonomy, which is often used interchangeably with self-governance or self-determination, is defined as a state where one's beliefs, intentions, and actions are not controlled by someone else (Mengay, 2020). On the one hand, working for algorithmic platforms offer high degrees of flexibility, autonomy, task variety, and complexity (Wood *et al.*, 2019). Workers are free to choose when and how much they wish to work, thereby being able to pursue a life balance between working and other commitments. The absence of direct human managers also increases the sense of autonomy, allowing workers to execute tasks at their discretion (Wood, 2021). On the other hand, many papers underline the loss of autonomy due to power and information asymmetries embedded in the platform design features. For example, Uber and Lyft workers find it difficult to "pick and choose" since the platforms withhold essential information like customers' location or the delivery value before they accept the ride (Wood, 2021).

The welfare of individuals under an algorithmic work environment is investigated in various aspects, namely work certainty, overwork and social disconnection, and sense of belonging. On the one hand, algorithmic management assures work certainty by providing repeated job opportunities thanks to its matching algorithms. (Möhlmann *et al.*, 2021). On the other hand, the second party faces an increasing sense of insecurity and vulnerability due to the opacity of algorithmic decisions. Drivers, workers, and sellers from platforms like Upwork, Uber, and eBay expressed the same fear of their accounts being replaced or blocked with vague explanations (Amorim & Moda, 2020; Bucher *et al.*, 2021; Curchod *et al.*, 2020). Besides, workers in app-work and crowd-work also feel the pressure to work extra hours due to nudges and rating mechanisms, and also suffer from social isolation due to little interactions with peers and clients (Bucher *et al.*, 2021; Wood, 2021).

Organization-level effects discuss the changes in administrative control of the agent that employs algorithmic systems in management. Three significant discussions are the emergence of new roles, the demand for algorithmic competencies, and the reshaping of power relationships.

The emergence of new roles and the demand for algorithmic competencies stems from the need to interact and control algorithmic systems. Three emerging jobs are identified: trainers, explainers, and sustainers, which serve the roles of "teaching algorithms to perform organizational tasks, explaining their decision-making approach and ensuring the fairness and the effectiveness of algorithms" (Jarrahi *et al.*, 2021). The birth of new roles comes hand in hand with the demand for algorithmic competencies, namely data-centered analytical skills and the capabilities to understand, audit, and alter algorithms. This knowledge of algorithms can foster one's power and position while reducing the sense of autonomy of the other, resulting in power disparity within the organization (Jarrahi *et al.*, 2021)

The reform of managerial power refers to the fact that algorithmic management can simultaneously increase and decrease the power of contemporary managers. On the one hand, managers now overcome the hardship of data overload. CV screening, work arrangement, or worker performance reporting are assisted

automatically by algorithms, thereby improving managing quality (Jarrahi *et al.*, 2021). Moreover, the imbalances in the accessibility to data between managers and workers also bolster power asymmetries (Jarrahi *et al.*, 2021; Mengay, 2020; Onsrud & Campbell, 2020). Many studies show that by withholding essential information, platforms are able to direct workers' behavior towards the organization's goals. On the other hand, algorithmic control is also taking away power from managers, especially the middle and upper levels. Depending on the degree of delegation of decision-making to an algorithmic system, the manager's ability to assess and intervene in management decisions will be limited. The managers shall be urged to withdraw from mundane and data-centric tasks and develop other skills requiring "social intelligence, tacit understanding, or imagination" (Jarrahi *et al.*, 2021).

Macro-level effects discuss the potential impacts of algorithmic control on society and the economy in general. Onsrud & Campbell (2020) bring attention to the sign of surveillance capitalism, meaning human experience will be transformed into behavioral data, then be traded on the marketplace as a new kind of commodity. The authors, therefore, voice concerns over the detriment of human self-governance and the growing economic disparity. In addition to surveillance capitalism, social coalitions are anticipated by S.tark & Pais (2020). Departed from the coalitions of the buyers and the platform's owner at the transactional level, the authors raise anticipation about the coalitions at the societal level. For example, the platform's owners, after gaining a large loyal customer base, could then use them to "secure favorable regulation".

Second party's responses to algorithmic management

This dimension involves the studies of the second party's *perceptions* of algorithmic management decisions, often in comparison with human decisions, as well as literature that attempts to identify and elucidate their *reactions* to the controlling mechanism.

Perceptions and attitudes toward algorithmic management engage the studies of individuals' various and complex psychological responses to algorithmic decisions. For example, with technical tasks, workers perceive algorithmic decisions as "legitimate" or "equally fair and trustworthy" as that human managers since they perceive the system as efficient and objective (Lee, 2018; Wiener *et al.*, 2021). Similarly, drivers of a French food-delivery platform perceived the incentive scheme and working scheduling performed by algorithms as "fair and meritocratic", meaning workers who outperform deserve better opportunities (Galière, 2020). However, when attention is brought to human tasks, algorithmic decisions are perceived as less fair and trustworthy and evoke negative emotions (Lee, 2018). Besides the studies of workers' perceptions, researchers also steer attention to the contemporary attitudes towards algorithms, namely algorithm aversion and cognitive complacency. The former refers to the reluctance to use algorithmic inferences after observing unsatisfactory performance by algorithms, while the latter implies the overreliance on the automated system, that organizations count on the system's output without questioning underlying driven factors (Jarrahi *et al.*, 2021).

Reaction topics include literature that focuses on discovering, explaining, and contextualizing a standard set of actions in response to algorithmic management from the second party. Despite the variety of terms and labels used in describing these reactions, we identified two typical reaction tendencies: cooperation and resistance.

Cooperation behaviors include courses of action that welcome algorithmic control and exhibit low resistance. Variants of cooperation can be blending, embracing, consent, and compliance (Bucher *et al.*, 2021; Galière, 2020; Möhlmann *et al.*, 2021; Pregenzer *et al.*, n.d.). In the case of Uber, blending behaviors can be demonstrated by "exerting effort to satisfy customers" and embracing feedback from the rating mechanism to improve their service. Pregenzer *et al.*, n.d. reconceptualize these reactions as a type of consent to algorithmic management since workers perceived algorithms as an efficient and objective tool of service. However, the second party may also demonstrate compliance mainly due to the fear of punishment. As evidenced by Upwork's case, workers attempt to develop a better understanding of the algorithms, stay under supervision, and keep their emotions in check primarily to avoid unfavorable reviews and being suspended from the platforms (Bucher *et al.*, 2021; Jarrahi & Sutherland, 2018).

Resistance behaviors are the most debated reactions in the studies about the second party' responses under algorithmic control. Resistance, which emerges in many papers as "algoactivism", can be in the form of collective and individual actions. Regarding collective resistance, the second party from online platforms

like Upwork, Uber, and eBay organize online forums and create associations to help each other learn a new system and avoid discipline mechanisms from the platforms (Curchod *et al.*, 2020; Kellogg *et al.*, 2020). Collective reactions can escalate to organizing strikes, suing platforms in court, and forming a union to pressure platform operators (Möhlmann *et al.*, 2021). Individual resistance can be shown in various forms: circumventing, bypassing, gaming, or separating from the system. An example of bypassing eBay shows that sellers attempted to deal with the customer in person by contacting the buyers who had given a negative evaluation and persuading them to withdraw it (Curchod *et al.*, 2020). Likewise, Upwork's workers circumvent algorithmic monitoring by switching from working on a computer to a tablet

Concerns around algorithmic management

The fact that algorithms have become more commonplace in organizational management has posed critical questions for the public and regulators. Inspired by the idea of viewing algorithmic management through the socio-technical concept, we found two classes of concerns around the deployment of algorithmic control, which are socio- and design concerns.

Socio-concerns include issues that do not stem from the technological nature of algorithmic systems and usually are strongly associated with the responsibility of the organizations that employ algorithmic management. The frequent debates are around data privacy, power asymmetries, the accountability of relevant stakeholders, and employment relations. Data is the core input for algorithmic decision-making, yet, how and to which extent data is collected is often an ambiguity to the public. The imbalance in data ownership fuels the power imbalances between the first party and the second party, reducing the self-governance abilities of the individuals subject to algorithms' control (Curchod *et al.*, 2020; Onsrud & Campbell, 2020; Stark & Pais, 2020). Moreover, researchers also raise concerns over organizational accountability for algorithmically-driven decisions. When coping with systemic discrimination, it is problematic to identify one's accountability due to a multiplicity of stakeholders (Jarrahi *et al.*, 2021). Lastly, the issue of employment relations is a heated discussion in the rise of the platform economy. Mengay (2020) calls for a way to "give dependent self-employed workers the same rights and protections employees have".

Design concerns include issues that derive from the way algorithms are programmed and the design feature of the management system. The common discussions are system *transparency* and *fairness*. Parent-Rocheleau and Parker (2021) explained that both are interconnected and can "mitigate the effects of algorithmic management".

Transparency reflects the degree to which an algorithmic system explains its reasons and actions (Jabagi *et al.*, 2020; Parent-Rocheleau and Parker; 2021). While employees can refer to a manager for help or feedback in traditional work contexts, gig workers are stuck with occasional messages with standard tips or automated nudges (Ens, 2019; Gal *et al.*, 2020). Missing quality feedback from algorithmic management, the second parties develop a sense of injustice (Jabagi *et al.*, 2020). Moreover, a low level of transparency also presents in the form of information asymmetry in gig works. Workers receive limited information formulated by an algorithm so that unpopular jobs cannot be identified and rejected at the early stages (Möhlmann and Zalmanson, 2017). Page *et al.* (2017) mentioned that due to the lack of information, platform workers also experience role ambiguity. Moreover, the situation is only aggravated by the fact that the algorithms are constantly changing, and platform workers, along with a large amount of information provided, cannot independently develop at least some strategies for interacting with the algorithm (Ens, 2019).

Algorithmic *fairness* is often presented in the form of biases and discrimination. Algorithmic decisions are the products of the organization's data and the technology infrastructure. If the history of the company's decisions displays patterns of discrimination and biases, it will be "learned" by the algorithms. For example, Amazon scrapped its recruiting engine as it did not rank technical posts gender-neutrally due to a 10-year history of favoring males in the IT industry (Jarrahi *et al.*, 2021).

Design of algorithmic management

The design of algorithmic management encompasses papers that describe algorithmic management from a technical-related viewpoint, including the conceptual lenses: *types of algorithms, degrees of automation,* and *sociomateriality*.

Types of algorithms include descriptive, predictive, and prescriptive algorithms (Parent-Rochelau and Parker, 2021). First, descriptive algorithms are employed to analyze worker-generated data by extraction, sorting, and cleaning and to perform simple statistics that show mean scores, distributions, or correlations between variables. Second, predictive algorithms are used for predicting the probability that an event or outcome will occur. Lastly, prescriptive algorithms follow the outcome of predictive algorithms by "including simulations and scenario-based techniques to propose what should be done in the light of possible scenarios" (Meijerink & Bondarouk, 2021).

Degrees of automation are associated with the possibility of human managers' intervention in the algorithmic system. Wood (2021) suggests a classification framework of three degrees of automation, that are conditional automation, high automation, and full automation, meaning as the algorithmic system performs management functions, the human manager will either be expected to intervene, able to intervene if needed, or unable to intervene, respectively. The use of algorithms in decision-making is critical to the platform economy for the ambition to scale up a mediated business that engages a large number of service providers and service recipients.

Sociomateriality, also known as the socio-technical perspective of algorithmic management, describes algorithmic management as a product of the interaction between social and technological forces. Looking beyond the "data-driven technological infrastructures", Jarrahi *et al.* (2021) bring to attention the sense of purpose of algorithms, that algorithmic systems must be intentionally fed and trained with organizational data to serve the organization's goals. The algorithms can learn the historical sequences of biases, discriminations, and inequalities embedded in the history of organizational decision-making and reflected in the algorithmic inferences.

Policy implications

Policy implications consider objects that suggest solutions to the concerns around the uses of algorithmic management and present remedies to the potential harms that it may cause.

Legal enforcement includes the review of the current laws and the proposals for law revisions. One crucial regulation that the EU enacted in 2018 is General Data Protection Regulation (GDPR), which provides "the right not to be subject to a decision based solely on automated processing that significantly affects them". In other words, a fully automated algorithmic management without input from human managers would not be legally allowed in the EU and the UK (Wood, 2021). Additionally, Onsrud & Campbell (2020) suggest revising the law of personal private data to balance the interest between humans, business, and government. Considering the complexity and opaque nature of the algorithmic system, Nowik (2021) proposes to form a new legal entity, so-called electronic personhood, that is responsible for settling disputes and accountability concerns around algorithmic management

Alternative suggestions include non-legal solutions to the issues around the use of algorithms in management. The principle of 'human-in-command' is advocated by researchers, in which workers are involved in implementing algorithmic management to assure their autonomy and control (Wood, 2021). Moreover, the deployment of any new technologies should be consulted with employee representatives. In France, for example, the implementation of new monitoring systems must be consulted with the works council. Other papers suggest a reframing of the algorithms and more attention to the data quality improvement for the sake of reducing negative emotions and biases in algorithmic output Gal *et al.*, 2020; Baier *et al.*, 2019

Others

Mistakes in automation decision-making (ADM) are classified into two types, category and process. While the former refers to false positives (Type I errors) that refer to an incorrect label assignment and false negatives (Type II errors) that are responsible for the incorrect exclusion from a category, the latter implies that algorithms can make mistakes during the decision-making process (Martin, 2019).

Research opportunities provide light on the most recent tensions that arise in organizations due to the implementation of algorithmic management. Benbya *et al.* (2021), for example, conducted a list of suggestions concerning the four business capabilities: automation, engagement, insight/decision-making, and innovation.

Driven factors to the second party's perceptions cover five characteristics of algorithmic management, including the system, the tasks, the second and the third parties, the output and outcome, and the decision-making process. Information on these topics would provide a better understanding of the system and the extent to which it should be trusted (Langer and Landers, 2021).

Platform urbanism is "a concept that captures the urbanization of algorithmic business models and sharing economies" (Pollio, 2021). The concept refers to transforming the urban spaces to benefit gig businesses, e.g., adding direction signs in airports to guide people to Uber cars or special parking lots (Pollio, 2021).

Conclusion

Given the development nature of our paper, the occurred limitations might provide opportunities for future research. First, unlike other researchers, we based our work on the information obtained from the existing literature and did not perform any original investigations, e.g., interviews, and model development. Secondly, we focused on the theoretical part of the question and did not include any coding in our work. Therefore, this research lacks a discussion of the technical issues related to algorithmic management. Thirdly, this study provides a general description of the topics related to algorithmic management and their classification since we focused on covering more issues instead of giving a detailed picture. Future research should mind these gaps and address them in future investigations.

The following steps in the investigation of algorithmic management should include the following. Firstly, we want to emphasize the necessity to give algorithmic management a single commonly accepted definition. Moreover, researchers should list all the alternative names of algorithmic management and either confirm their equality or explain the differences. This would provide more clarity for further research and eliminate the potential misunderstanding and confusion. During our research, we mentioned that many algorithmic management articles focus on single companies rather than the industry. Therefore, we suggest working on the comparison of the experiences among several firms. Due to the closeness of the algorithm nature, the most popular information source for the researchers is the interviews. Unfortunately, such information lacks consistency and might not be perceived earnestly. Therefore, we suggest working on alternative ways to obtain the information. Besides, the existing literature is missing the opinion of the first parties. Such research might provide additional insights and enlighten the dark spots in the field. Other suggestions for future research include the investigation of the ways to increase the transparency level and the ways to reduce social isolation.

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