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Algorithmic Management

Consequences for Work Organisation and Working Conditions

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Algorithmic Management

Consequences for Work Organisation and Working Conditions

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Abstract

The use of software algorithms to automate organisational functions traditionally carried out by human managers has been termed 'algorithmic management' and identified in both platform work and conventional employment settings. Algorithmic management has been researched in greatest detail in the settings of platform work and warehousing but also noted to a lesser extent in retail, manufacturing, marketing, consultancy, banking, hotels, call centres, and among journalists, lawyers and the police. This working paper reviews industry examples from the above sectors along with more detailed case studies of platform work. Doing so enables the outlining of the main ways in which algorithms are deployed to automate workforce direction, evaluation and discipline. A new framework is presented for differentiating algorithmic management from algorithmic assistance and whether it constitutes partial, conditional, high, or full automation. The working paper also highlights some potential consequences of algorithmic management for work organisation and working conditions. In particular, the existing evidence suggests that algorithmic management may accelerate and expand precarious fissured employment relations (via outsourcing, franchising, temporary work agencies, labour brokers and digital labour platforms). It may also worsen working conditions by increasing standardisation and reducing opportunities for discretion and intrinsic skill use. Evidence from platform work and logistics highlights the danger of algorithmic management intensifying work effort, creating new sources of algorithmic insecurity and fuelling workplace resistance. Finally, the implications for policy are considered and remedies to the potential harms of algorithmic management considered.

Keywords: Algorithmic management, Work organisation, Working conditions, platform work

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1 Introduction to and definition of Algorithmic Management

An algorithm is a 'process or set of rules to be followed in calculations or other problem-solving operations' (OED Online, 2021). The use of algorithms by business can be traced back to at least the 19th century and Max Weber famously 'discussed the step-by-step, distributed and nominally objective procedures for selection and sorting that characterized decision-making in modern bureaucracies' (Fourcade and Healy, 2017: 10). However, while the use of algorithms has a long history, their use has taken on a qualitatively different dimension in recent times due to an explosion in computing power and digital data collection. Consequently, research into 'algorithmic management' as opposed to 'management's use of algorithms' focuses on software algorithms, defined as 'computer-programmed procedures for transforming input data into a desired output' (Kellogg et al., 2020: 341; see also Barocas et al., 2014; Gillespie, 2014). Algorithmic management, therefore, refers to the use of such computer procedures in the controlling of an organisation. As technological developments have increasingly extended the scope for the collection and processing of input data such as cameras, sensors, audio devices, biometrics and text, so too has the potential economic advantages of algorithmic decision making (Kellogg et al., 2020). Algorithmic management was first coined by Lee et al. (2015: 1603), who defined it as relating to 'software algorithms that assume managerial functions and surrounding institutional devices that support algorithms in practice.' According to Lee et al., (2015: 1603), this algorithmic management entailed human jobs being 'assigned, optimized, and evaluated through algorithms.' Likewise, Mateescu and Nguyen (2019: 1) define algorithmic management as 'a diverse set of technological tools and techniques to remotely manage workforces, relying on data collection and surveillance of workers to enable automated or semi-automated decision-making.'

Kellogg et al. (2020) highlight that existing empirical research suggests that, at present, algorithmic management is mainly confined to the reshaping of organisational control through the *automation of direction* (what needs to be done, in what order and time period, and with different degrees of accuracy); *evaluation* (the review of workers' activities to correct mistakes, assess performance, and identify those who are not performing adequately); and *discipline* (the punishment and reward of workers in order to elicit cooperation and enforce compliance).

At present, no large-scale representative research into algorithmic management has been undertaken. Therefore, the research that does exist is based upon qualitative case studies, much of which has been undertaken in the empirical setting of platform work. Digital labour platforms are digital infrastructures (Srnicsek, 2016) that operate as intermediaries within multi-sided markets that bring together two or more distinct user groups (Rochet and Tirole, 2003; Evans, 2003; Eisenmann et al., 2006; Wood and Lehdonvirta, in press). Thus, platforms have the potential to enable workers to individually contract with a multiplicity of clients and customers, and, to varying degrees, are able to choose the clients and jobs they take, how they carry out those jobs, and, in a majority of cases, the rates they charge to do them. However, in reality, workers' ability to realise this agency is strongly shaped by platform rules and design features (Wood and Lehdonvirta, in press). Data collection and algorithms are central to the functioning of digital labour platforms and, therefore, it is unsurprising that it is in this sector that algorithmic management first developed (Mateescu and Nguyen, 2019). However, increasingly, aspects of algorithmic management have been identified in conventional employment settings, most significantly in warehouses but also to a lesser degree in retail, manufacturing, marketing, consultancy, banking, hotels, call centres, and among journalists, lawyers and the police. In the following sections, industry examples from the above sectors with more detailed case studies of platform work are presented. Doing so enables the outlining of the main ways in which algorithms are deployed to automate workforce direction, evaluation and discipline. The following review of literature highlights that algorithmic management has, at present, been largely confined to enabling the automatic direction, evaluation, and discipline of workers (see also Kellogg et al. (2020)). The next section will investigate each of these three functions of algorithmic management in both platform work and conventional employment.

2 The use of algorithmic management practices in different contexts

2.1 Algorithmic direction

2.1.1 *Algorithmic direction in platform work*

This section investigates the use algorithms in the workplace to automate the direction of workers, in terms of what needs to be done, in what order and in which time period (Kellogg et al., 2020). However, it should be noted that direction also entails a host of affective personnel management functions that algorithms are, at present, unable to fulfil.

In platform work, algorithms assume some management functions by automatically allocating tasks to workers via handheld devices, smartphones and computers (Gent, 2018; Ivanova et al., 2018; Lee et al. 2015; Lehdonvirta, 2018; Rosenblat and Stark, 2016; Shapiro, 2018; Veen et al., 2019). For instance, Lee et al. (2015) find that once 'ride-hail' drivers in the US have turned on their smartphone app they receive trip requests with a 15-second window to accept the 'gig'. If they accept the request they are then provided with the passenger's location via the app's map display. Lee et al. (2015) detail how the limited time frame provided by the algorithm for rejecting a gig leaves workers with little option but to accept the system's allocation of work. As one informant explained:

'I mean you can always decline to pick up a passenger if you can make that decision within 12 seconds. [Uber/Lyft] make it sort of difficult to say no for a couple of reasons. [...] when they show the spot on the map where you're going to pick someone up it's very zoomed-in so if you're not immediately familiar with the area you probably wouldn't be able to discern within 12 seconds if its somewhere you want to go or not. They just tell you how far away it is in driving time (P4)' (Lee et al., 2015: 1606).

Rosenblat and Stark's (2016) similar study also finds that by withholding key information, such as the fare and destination, platforms further restrict the ability of workers to decline trips allocated to them algorithmically. Bloodworth's (2018) ethnographic study in the United Kingdom (UK) highlights that workers had to accept 80% of tasks automatically allocated to them and were logged out of the app for 10 minutes if they did not accept a journey. As Bloodworth (2018: 225) was informed during his 'onboarding':

'The reason you're online is to accept any job that's given to you... How Uber works is that you can't pick and choose. You can't pick and choose which jobs you want.'

Bloodworth (2018) also states that the Uber app directs the route taken to reach the customer's destination. Rosenblat and Stark (2016) highlight that workers in their US study could have their pay docked for not following an 'efficient route' if they choose not to follow the platforms instructions. Rosenblat and Stark (2016) also detail Uber drivers are directed to charge customers a maximum fare by the platform based on distance, city and labour supply.

Food delivery platform workers likewise receive automated instructions via a handheld device or a smartphone regarding the allocation of work and where to collect/drop off food and the route they should take in doing so (Gent, 2018; Ivanova et al., 2018; Veen et al., 2020). A study of Deliveroo and Foodora in Germany by Ivanova et al. (2018) finds that once workers have logged on to the smartphone app they automatically receive instructions to go to waiting points, restaurants and delivery addresses. As with Uber and Lyft, while formally workers can choose not to accept orders, their ability to ignore this algorithmic direction is severely constrained by information asymmetries in which they do not know the location of the customer or the value of the delivery. Veen et al. (2020) find a similar situation with the algorithmic management of food delivery workers by Deliveroo and UberEATS in Australia. In this study, the apps are found to recommend routes for reaching drop-off locations but that workers can take alternative routes if they wish. Nevertheless, their agency to do so is, in reality, limited by their awareness that their route is being monitored. In fact,

workers receive calls or text messages from the platform if they have headed in the wrong direction or taken longer than the algorithmically estimated time. As one worker remarked ‘you just do what you’re told by the app’ (Veen et al., 2020: 396). In line with Australian study of Veen et al. (2020), Ivanova et al. (2018) find that Deliveroo workers in Berlin receive notifications if the GPS on their smartphone indicates they are not moving while Foodora workers are automatically notified by the app to end the order and contact a dispatcher if it takes longer than the calculated time. These workers are also instructed by the app to contact a dispatcher if they are too slow in accepting an order, or take too long at a restaurant. However, Gregory and Maldonado (2020) provide a detailed account of how Deliveroo workers in Edinburgh nevertheless retain agency that shapes how algorithmic direction plays out in reality. These researchers demonstrate that the routes taken by workers are shaped by a combination of algorithmic affordances, geography, risks and worker agency.

Importantly, Ivanova et al. (2018: 13) highlight the continued importance of human managers and supervision despite the use of algorithmic management, explaining that both Deliveroo and Foodora continue to employ ‘dispatchers’ who ‘monitor riders and orders in real-time and help solve ‘issues’. This finding highlights that the realisation of algorithmic management in its ideal typical form, in which algorithms completely assume managerial functions, may in reality be rare, as managerial agency at crucial points and moments remains an important element within the managerial circuit. That algorithmic management entails the systematic and integrated assemblage of human and automated decision making will be highlighted further below and discussed in Section 4.

Similar uses of algorithms to allocate jobs to workers and provide them with automated instructions have also been documented in courier and parcel delivery platform work. Shapiro’s (2018) study of couriers in the United States details how Caviar and Postmates workers could formally choose to accept or reject tasks algorithmically allocated to them but that informational asymmetries regarding drop-off address, pricing and the consequences of rejecting an order limited their ability to do so in reality. Gent’s (2018) study of algorithmic management in the UK details the algorithmic direction of delivery workers via a smartphone app. This app instructs workers when to check into warehouses and then provides them with a GPS map to follow in making deliveries. Importantly, and unlike the algorithmic direction faced by many other delivery works, this app did not allow workers to use alternative GPS apps for navigation. The app was also responsible for paying workers. Gent (2018) reports that logging out of the app without having completed all deliveries could result in the app refusing to release the worker’s automatic payment.

2.1.2 Algorithmic direction in conventional employment settings

While algorithmic direction is central to many types of platform work, it has also been identified in conventional employment settings, such as warehouses (Delfanti, 2019; Gent, 2018), factories (Bri ne, 2017; Bri ne, 2020), and even, marketing firms (Bri ne, 2020; Walsh, 2019). Studies of Amazon’s warehouses in Italy (Delfanti, 2019) and the UK (Gent, 2018) detail how algorithmic management operates via handheld devices or scan ‘guns’ that combine barcode scanners, motion and location tracking, and a display (such as the Motorola MC3000). Delfanti (2019) highlights that Amazon’s use of ‘chaotic storage’, whereby products are not stored in an ordered manner leaves workers reliant on algorithmic instructions relayed to them via their handheld device. When stowing a product in the warehouse, workers follow a few basic rules in storing a product and then scan the product’s location with their device. This enables Amazon’s software system to know the exact location of each product and to automatically assign the optimal item to workers in terms of efficiency by factoring in their relative locations as well as the location of other workers who might otherwise get in the way. Once an item has been allocated to a worker this is communicated to them via their text and images displayed on their hand-held device. The device also plans in real-time, taking into account the location of stock and other workers, the route to be taken and communicates this step by step to the worker as well as the item’s position on the shelves. The handheld device also communicates the time a worker has to complete the task (referred to as a ‘pick-rate’) – usually around a minute (Delfanti, 2019; Gent, 2018). As the worker places each product into a box on their trolley

they scan the barcode of both box and the item and their device approves the placement (Delfanti, 2019: 9). Once a worker's shift is complete or the trolley is full, another worker is instructed via the handheld device how to sort the products (Delfanti, 2019; Gent, 2018). In response to the COVID-19 pandemic, Amazon has been reported in the US to have installed cameras in its warehouses that use machine learning to alert workers when they are breaking social distancing rules (Palmer, 2020).

Gent's (2018) study of algorithmic management in the UK details the use of wearable devices among supermarket warehouse workers. These devices, such as the Motorola WT4000 series, combine a scanner worn as a finger ring with a display and computer worn on the arm. The benefit of wearable devices over handheld ones is that they leave worker's hands free for moving and manipulating stock. Gent (2018) documents how workers receive instructions via text and images on the screen of their wearable device as to where they need to go and which products to move from storage cages onto their pallet. As the worker places the item they scan both the cage and the product and confirm its receipt on to their pallet via buttons on the device. It has been reported that Amazon has installed *Driveri*, AI-equipped cameras in Amazon-branded vehicles of some of their outsourced 'delivery service partners'. These cameras capture the road ahead, the driver, and both sides of the vehicle and instruct the worker to take specific actions in response to what are deemed safety violations. For example, it will instruct workers to maintain safe distance with other vehicles, to slow down if breaking the speed limit, not to engage in unplanned stops and to take a 15-minute break if captured yawning (Palmer, 2021).

Algorithms have been used to allocate work in other conventional employment settings. Computer software is frequently used in retail and hospitality to algorithmically schedule workers based upon forecast customer demand and skills matching (Bri ne, 2020; O'Connor, 2016; S nchez-Monedero and Dencik, 2019; Van Oort, 2019; Wood, 2020). Van Oort's (2018) study of two US retailers highlights the use of the *Kronos* management system that combines workforce information with data on customer traffic and the weather to automatically schedule workers. Van Oort (2018) findings suggest that the use of this system heightens short shifts and fluctuating schedules. Indeed, it has been reported that when retailers *Forever 21* and *Century 21* began using *Kronos* 'hundreds of full-time workers were notified that they'd be switched to part-time and that their health benefits would be terminated' (Kaplan, 2015: 36). Another workforce management system that has been reported to be used by around 40 retailers, including *Uniqlo* and *7-Eleven* is *Percolata*. In workplaces where this system is used workers receive schedules via their smartphone. *Percolata* aims to ensure the optimal mix of workers for maximising sales in every 15-minute slot of the day. To achieve this aim the system allocates schedules on the basis of predictions of demand. The variables used to generate these predictions include weather forecasts, online traffic, public holidays, in-store promotions and previous sales, as well as real-time customer flows captured by sensors in shops and individual-level sales data. Workers are also ranked according to sales productivity and profiled in terms of the times and the team combinations in which sales productivity is highest (Bri ne, 2020; O'Conner, 2016). However, it is important to note that while *Percolata* has the ability to automatically schedule workers, the company reports that this functionality is often not used by store managers who prefer to use the system's customer demand predictions to instead inform their own manual scheduling of workers (Bri ne, 2020). Again this reminds us that the ideal of algorithmic management, in which algorithms completely assume managerial functions, may, in reality, be rare, even when technically feasible, and human managers retain crucial decision-making powers in the managerial circuit.

Algorithmic work allocation and instruction has also been identified in advanced manufacturing plants. Bri ne (2017; 2020) highlights the use of algorithmic management at *Siemens'* Congleton electrical component factory in the UK. This plant uses *Preactor* planning and scheduling software that plans production in real-time and instructs workers as to what needs to be produced each day. The software provides 'a specific set of instructions... which tells... [workers] exactly what order to carry out each step [in the production process]' (Bri ne, 2017: 17). The use of this software to se-

quence production leaves workers with very little autonomy in the selection and ordering of their day-to-day tasks (Bri ne, 2020).

Algorithmic work allocation has also been noted in white-collar work. For instance, *Klick Health*, a large Canadian healthcare consulting firm, uses a passive data collection system and machine learning tool called *Genome*. *Genome* is used to calculate the average time it takes to complete a variety of tasks and alert team leaders when projects are behind schedule. This system notifies project leaders of outstanding and urgent things to do. The company also uses a data tool called *RescueTime* that seeks to reduce distractions that may be impacting workers' productivity (Schweyer, 2018). *Publicis* – a multinational marketing firm with 80,000 employees – uses computer algorithms to assign account managers, coders, graphic designers, and copywriters to new projects (Bri ne, 2020; Walsh, 2019).

In summary, this section has highlighted how algorithmic management in platform work has been used to enable the automatic allocation of tasks to platform workers, to direct them to locations and instruct them in the routes they should follow when undertaking their work and how long they should take in undertaking them. In conventional sectors algorithmic management has also been used to automatically allocate tasks to workers, to schedule workforces, and direct workers in the routes and time they should take in completing their work activity. However, examples where these systems are completely autonomous in their direction of workers are seemingly rare. For instance, food delivery platforms Deliveroo and Foodora retain supervisory-level staff who monitor workflow and solve any issues that arise in real-time. Additionally, while both delivery and ride-hailing platforms limit the ability of workers to ignore and override the algorithmic directions they receive, it remains the case that it is possible to do so – although it may require justification to a human manager. The absence of this human input into the system would in practice reduce the efficiency of algorithmic management. In conventional employment settings the ability of workers to ignore or override algorithmic direction is more limited but here the continuing oversight of human managers is also more pronounced. As is apparent by the fact that the potential for software to autonomously schedule workers is often not taken advantage of by firms. Additionally, the continuing importance of human managers in algorithmic management systems will become clearer as we review the literature on evaluation and discipline in the following sections. The discussion section will then consider the degree to which algorithmic management entails partial, conditional, high, or full automation.

2.2 Algorithmic Evaluation

2.2.1 Algorithmic evaluation in platform work

Algorithms are used to evaluate workers in platform work via reputational systems that rank workers on the basis of customer-generated ratings (Gandini, 2019; Veen et al., 2019; Lee et al., 2015; Rosenblat and Stark, 2016; Wood et al., 2019). Studies of Uber and Lyft in the US by Lee et al. (2015) and Rosenblat and Stark (2016) highlight that these platforms use customer ratings and work acceptance rates to algorithmically evaluate workers. Rosenblat and Stark (2016: 3771) highlight that the use of customer ratings entails using customers as 'a type of managerial assessment'. Passengers rate drivers on a scale of one to five stars (Rosenblat and Stark, 2016: 3774-3775), and drivers then receive weekly performance metrics via an app on their smartphone. These smartphone apps also collect personalised data on braking and acceleration speeds in order to further evaluate driving performance and algorithmically recommend workers who are driving erratically take a break (Kellogg et al., 2020; Ticona et al., 2018). Digital labour platforms which provide remote services, such as data entry, design, marketing, translation, transcription, and programming, also use weighted customer-generated ratings combined and other metrics such as jobs completed and length of relationship to algorithmically evaluate workers. These platforms also remotely evaluate worker productivity in terms of keyboard presses and screenshots that are displayed to customers (Wood et al., 2019)

Food delivery platforms have been found to evaluate worker performance via smartphone apps (Ivanova et al., 2018; Veen et al., 2020). A study of this work in Germany found that Foodora workers are evaluated via a ranking algorithm that uses six weighted metrics: ‘weekend shifts after 8pm (30%), average weekly hours (25%), no-shows (25%), percent late log-ins (5%), orders hour deviation (10%), experience working with the company (5%)’ (Ivanova et al., 2018: 15). Deliveroo’s algorithmic evaluation was found to be based on two metrics collected by the smartphone app: ‘no-shows and late log-ins (defined as cancelling your shift within less than 24 hours, and logging-in for work more than 15 minutes late, respectively). A study of Deliveroo in Australia finds that a more extensive range of metrics are used for algorithmic evaluation in this setting, with the app collecting data on the ‘time to accept orders, travel time to restaurants, travel time to customers, time at the customers, unassigned orders [i.e. orders not accepted by the worker]’ (Veen et al., 2020: 397). Veen et al. (2020) also find that UberEATS performance metrics incorporate customer ratings – resembling those used in its ride-hailing business. This customer rating metric was based upon the customer using the app to give a rider’s performance a thumbs up or thumbs down once the delivery was completed. The other metrics that informed UberEATS algorithmic evaluation were found to be the proportion of orders accepted or rejected upon receiving a delivery request and the number of orders cancelled after acceptance (Veen et al., 2020).

2.2.2 Algorithmic evaluation in conventional sectors

The algorithmic evaluation of workers has also been identified in more traditional sectors of the economy. Wood’s (2020) study of a major US retailer highlights the use of the algorithmic *My-Guide* system which has preprogrammed time frames for basic tasks, such as putting out a specified number of pallets of goods in a specific department – failure to meet the allocated time is flagged up to management. Paralleling the importance of customer ratings in platform work, Orlikowski and Scott’s (2014) study of hotels finds that online ratings and reviews from the TripAdvisor website were often incorporated into both individual performance management and also weekly team meetings. As a result, staff felt they were under ‘constant surveillance’ from customers (Orlikowski and Scott, 2014: 886). In call centres programmes, such as *Cogito*, have also been used to provide both real-time and recorded activity productivity assessments that can be viewed by both workers and managers (Bri ne, 2020). The algorithmic evaluation provided by *Cogito* includes real-time voice evaluation. As Roose (2019) explains:

‘Talking too fast? The program flashes an icon of a speedometer, indicating that he should slow down. Sound sleepy? The software displays an “energy cue,” with a picture of a coffee cup. Not empathetic enough? A heart icon pops up’.

The Driveri AI-enabled cameras installed in delivery vehicles by Amazon are reported to detect ‘16 different safety issues, including if drivers fail to stop at a stop sign, distracted driving, speeding, hard braking and whether the driver is wearing a seatbelt... [or] when a driver is yawning (Palmer, 2021). When the camera deems that a worker is driving in an unsafe manner it automatically uploads the footage and flags the behaviour to managers in real-time. Footage collected by the cameras can be used for employment decisions such as disciplinary actions (Palmer, 2021).

Consultancy and banking firms have also increasingly adopted software that enables continuous real-time performance reviews (Kessler, 2017). At Deloitte team leaders rate employees on four questions at the end of each project (or once a quarter for bigger projects). These ratings are then aggregated with each data point weighted according to the length of the project and plotted on a workforce data distribution so as to provide continuous performance snapshot that informs performance management decisions (Buckingham and Goodall, 2015).

However, despite the increasing spread of algorithmic evaluation within conventional employment sectors, it remains, perhaps, most prominent in the warehouse sector. Handheld and wearable devices are used to produce metrics on productivity (i.e. collection of products, or ‘pick rate’) and to create rankings of worker performance (Delfanti, 2019; Gent, 2018; McClelland, 2012; Moore and Robinson, 2016). McClelland (2012) documents how managers at one large warehouse received

continuous real-time information on whether workers were meeting performance targets in terms of pick rate. A low score automatically alerted a manager (Kellogg et al., 2020; McClelland, 2012).

Delfanti's (2019) study of Amazon warehouses in Italy details how workers start their shift by using their handheld device to scan their ID badge, they then scan each product as they collect it from the shelf enabling the device to record the number of products picked per hour. This pick rate is then compared to a target rate based upon previously achieved pick rates. Managers log in to the device and see the pick rate but also times that workers went to the bathroom or took breaks and the times they were working their fastest. This information is also aggregated with that from other workers in order to rank individual workers relative to their colleagues. The aggregated data is also discussed by managers in their team meetings and briefing. For example, telling workers 'yesterday we had an insane productivity rate!' (Delfanti, 2019: 11).

Maintaining the pick rate dictated by the device is seen as important for gaining permanent positions or moving to better roles (Delfanti, 2019). Briken and Taylor's (2018) study of Amazon in the UK finds that individual speed, productivity, accuracy and errors in real-time and retrospectively are bundled into a single, composite assessment of performance and matched to a normal distribution curve. Bloodworth (2018) reports that at the UK Amazon warehouse where he worked, data from workers' handheld device was used to automatically rank workers from highest to lowest with the lowest 10% being told to speed up by human managers. Likewise, Gent's (2018) study of Amazon warehouses in the UK also highlights how the role of low-level managers is limited to the giving of commands on the basis of algorithmic evaluation. As Gent (2018: 126) explains:

'Through the scanning of items, managers compile records of the workers' productivity rates both per assignment (pallet) and across the shift. Two main figures are communicated to workers: a percentage figure based on the company's hourly pick targets, and a cases per minute (CPM) rate.... "a supervisor of the temp agency... comes along and picks out people who are too slow and they show them a print out, they show them a print out which shows, let's say, up to the last half an hour what your pick rate was, and if it's, let's say, below ninety percent or something they say you have to work a bit harder... [you also] have screens where you can, at the end of the grid, when you return, you can see your own code and the percentage."

A further way in which the algorithmic evaluation of workers may take place in conventional employment settings is before a worker even starts work. This is due to the use of predictive analytics to sort candidates in the labour market (Kellogg et al., 2020). Hiring software tools such as Equifax, Kronos, SnagaJob, and Recruit, algorithmically process and sort applicants according to employer criteria, such as work history, identification information, schedule availability, background checks and personality and skill assessments (Ajunwa and Greene, 2018; Kellogg et al., 2020; Sánchez-Monedero and Dencik, 2019). The hiring tool HireVue even makes an automated pre-interview assessment of candidates via video interviews and online games. The software extracts three types of indicator data (categorical, audio and video) from these activities to build a profile of workers that can be compared to those already performing the job to identify those believed most likely to be successful at the job (Sánchez-Monedero et al. 2020).

In summary, this section has highlighted the use of algorithmic management in terms of the automatic evaluation of workers. It is in this managerial function that algorithmic management most fully approximates its ideal typical form whereby the system acts autonomously without the input of humans. Data generated from the digital recording of customer satisfaction ratings and workers' behaviour and biometrics (including their geolocation, voice and movement) are inputted into algorithms that autonomously evaluate, rate and score worker performance. However, even in this realm Gent (2018) highlights the role of warehouse managers and supervisors as conduits and interpreters of this algorithmic evaluation. As stated above the discussion section will consider the degree to which algorithmic management, in practice, entails partial, conditional, high, or full automation.

2.3 Algorithmic Discipline

2.3.1 *Algorithmic discipline in platform work*

Closely related to worker evaluation is the managerial function of discipline (i.e. the punishment and reward of workers in order to elicit cooperation and enforce compliance) (Kellogg et al., 2020). As with algorithmic direction and evaluation, it is in platform work that the use of algorithms to automatically discipline workers has been researched in greatest detail. In this sector, access to work via smartphones or computers is usually dependent on reputational rankings derived from customer ratings (Gandini, 2019; Rosenblat and Stark, 2016; Wood et al., 2019). Studies of ride-hailing platforms Uber and Lyft in the US highlight that workers with low customer ratings face automatic deactivation from the platforms (Lee et al. 2015; Rosenblat and Stark, 2016). Rosenblat and Stark (2016: 3774) find that Uber drivers have to ‘maintain a rating of around 4.6/5’ otherwise their account is deactivated and they are no longer able to work through the platform. As noted above these ratings are averaged to reflect their last 500 rated trips, although some drivers receive deactivation notices if their previous 25 or 50 trips receive low ratings’ (Rosenblat and Stark, 2016: 3774-3775). If workers receive a bad rating or are deactivated due to low ratings they do not have a right to appeal the decision but can contact Uber and ask for the rating or decision to be reviewed or in some cities undertake a ‘quality improvements course’ (at their own expense) in order to be reactivated. However, Uber has been accused of being unresponsive to worker requests, sending automated generic replies (Bernal, 2020). In response to a legal claim by former UK drivers (see below policy discussion), Uber has claimed that their deactivation were manually reviewed by a human manager (Moss, 2020) but at the time of writing Uber is yet to disclose evidence of how such manual reviews are undertaken and the degree to which they can be considered meaningful (see policy discussion below). Postmates delivery workers in the US have also been found to be deactivated from the platform if their average rating drops below a certain point (Shapiro, 2018). The digital labour platforms studied by Wood et al. (2019) do not deactivate workers if they have a low rating but work is algorithmically filtered away from those with low ratings, thus making continuing on the platform less viable. As one platform puts it ‘if your score falls below 75%, you may find it difficult to win new clients in the marketplace’ (Upwork, 2021).

There is also evidence of algorithmic discipline in the delivery sector of platform work. Here studies have highlighted how platforms automatically discipline workers by restricting access to shifts. Ivanova et al. (2018) find that Deliveroo and Foodora workers who are ranked badly by the algorithmic evaluation systems described above are automatically disciplined by having their ability to access the best shifts restricted. Workers are ranked and profiled to three worker categories, termed ‘badges’. Foodora allows workers in the top category of performers to book shifts on Mondays, second badge workers on Tuesdays and third badged workers on Wednesdays. Deliveroo allows top badged workers to book shifts 11am on Mondays, whereas second badged workers have to wait until 1pm and the last category until 5pm. As a result ‘riders in the lowest group might not have the chance to work when and where they prefer as their preferred shifts could be already fully-booked’ (Ivanova et al. 2018: 15). The UK Deliveroo workers studied by Gregory (2020) also face the same automated shift restriction if they fail to meet performance metrics.

2.3.2 *Algorithmic discipline in conventional employment settings.*

Beyond platform work, the automated termination of poorly performing workers is uncommon. However, there is evidence that the disciplinary function of managers is being augmented by algorithmic management tools. In particular, in the warehouse sector productivity metrics collected by handheld and wearable devices have been found to inform supervisors’ disciplinary actions. As supervisors place a great deal of trust in these automated metrics and ranking algorithms rather than using their own discretion their management function may be transformed into one of providing encouragement, tips and feedback sessions for increasing productivity (Bloodworth, 2018; Delfanti, 2019; Gent, 2018). Indeed Briken and Taylor’s (2018: 453) study of Amazon in UK finds that disciplinary decisions are based on individual performance scores which are used to decide who should be fired meaning that ‘management consists of executing decisions based on data analytics’.

Delfanti's (2019: 12) study of an Amazon warehouse in Italy found that this data would be used for individual 'feedback sessions' in which workers were told they are not meeting the team's targets. However, it has been reported that in at least one US Amazon warehouse terminations for low productivity are generated automatically without input from supervisors – although human managers can intervene in the process (Lecher, 2019). Additionally, the footage collected by the AI-enhanced cameras which Amazon installed in some vehicles of their outsourced 'delivery service providers' are used for disciplinary actions including firings (Palmer, 2021).

Gent (2018) finds that algorithmic discipline in warehouses can also take a similar form to that operated by digital labour platforms, such as Deliveroo, Foodora and Upwork, whereby access to work is automatically restricted in response to poor performance. Gent (2018) details how workers at one warehouse receive text messages via their phone in the mornings of the days they are down to work. These text messages confirm or cancel their shifts based on their previous day's productivity metrics. Although less well studied there are also examples of algorithmic discipline in white-collar work. In hospitality Orlikowski and Scott (2014: 868-891) report that algorithmic evaluations generated from online reviews result in workers being fired. As a result, Orlikowski and Scott (2014: 886) argue that hotel workers feel that 'every guest is their boss.'

In summary, this section has highlighted the use of algorithmic management in terms of the automatic disciplining of workers. Based on the algorithmic evaluation of workers outlined in the previous section, firms can automatically restrict access to future work. Workers deemed to be performing poorly by algorithmic evaluation systems have been found to have work automatically filtered to higher-performing workers, access to the best shifts blocked and have even been deactivated from a digital labour platform or fired from their job. However, this section has again highlighted that examples of the ideal typical form of algorithmic management – in which these systems act autonomously without the input of humans – is rare in practice. At a minimum, human managers can review and overrule algorithmic discipline, and in most cases it is the human manager that performs the act of discipline on behalf of the algorithm. These features of algorithmic discipline make it difficult to determine the degree to which a decision should primarily be located with a human or algorithmic actant. Indeed, Uber – which has been widely cited by academic research as automatically deactivating poorly performing workers – maintain that the deactivation of UK workers was manually reviewed by human managers. The role of humans in algorithmic management is a hotly debated topic with significant legal ramifications in many European countries. This will be discussed further in the discussion and policy implications in Section 4. Moreover, a framework will be presented for understanding the degree to which algorithmic management entails partial, conditional, high, or full automation.

3 The Consequences for work organisation and working conditions

Taking inspiration from Kellogg et al. (2020), Section 2 examined empirical research and detailed industry examples in order to highlight the ways and the extent to which algorithmic management reshapes organisational control. It demonstrates the use of algorithms by firms to direct workers in undertaking tasks, to evaluate their performance and to identify and discipline those workers who are not deemed to be performing adequately. Weil (2014) argues that firms have used information and communication technologies to create and enforce product and quality standards without the need for traditional employment relationships. According to Weil, this has led to a growth of fissured employment relations, this fissuring is argued to entail the opening up of non-core activities to cost competition and the shifting of risks for managing employment on to other entities. Weil (2014) identifies fissuring as taking place via outsourcing, franchising and the use of temporary work agencies and labour brokers. Wood and Lehdonvirta (in press) argue that digital labour platforms entail a further form of fissuring made possible by algorithmic management as well other market organising functions. Therefore, a potential consequence of the wider of adoption of algorithmic management beyond platform work may be an acceleration and expansion of fissured employment relations. In fact, Delfanti (2019) argues that this is the case at Amazon. Additionally, the

use of algorithmic management to automate tasks that would previously have been core management functions reduces the reliance of these firms on low-level managers and supervisors. As Lee et al. (2015: 1609) highlight this algorithmic management enables ‘a few managers in each city to oversee myriads of workers (hundreds in a city and thousands of drivers on a global scale) in an optimised manner at a large scale.’ A potential consequence of algorithmic direction then, for both managers and workers, is reduced intrinsic skill use and standardisation of work. As already noted algorithmic management has been found to reduce managerial agency (Briken and Taylor, 2018; Bloodworth, 2018; Delfanti, 2019; Gent, 2018). Delfanti’s (2019) study of an Italian Amazon warehouse highlights that algorithmic direction dispossesses workers of the knowledge that would otherwise be necessary to carry out the job. Algorithmic management then may reduce the need for firms to invest in skills and, as Delfanti (2019) argues, facilitate unstable and fissured employment relationships, such as the high number of temporary agency workers used by Amazon or the use of self-employed platform workers, by reducing the costs of replacing workers. Delfanti (2019: 10) highlights that Amazon’s training consisted of ‘crash courses for workers to learn a specific process... [churning out] masses of workers.’ By restricting opportunities for intrinsic skill use and discretion, algorithmic management may also damage employee well-being. Empirical studies have found that limited learning at work and influence over tasks reduces worker well-being (Felstead et al., 2019a).

Generally, new technologies in the workplace have been associated with ‘effort biased technical change’ (Rubery and Grimshaw, 2001). In particular, computerisation often intensifies work by increasing monitoring, raising its pace, minimising gaps in workflow and extending work activity beyond the conventional workplace and working day (Felstead et al., 2019b; Green, 2004). Delfanti’s (2019: 9) study of Amazon demonstrates a link between high work intensity and algorithmic direction, highlighting that workers are required to work at frantic pace and often have to run in order to keep up with the speed instructed by their handled devices:

‘As you are loading an object onto the cart, the next one appears on the scanner. So as you are loading your cart you start moving, and as you are arriving you already take a look at what you are to pick next, you don’t stop, and then you look at the shelf, is it a book or something else? In which area of the shelf is it?’ (Delfanti, 2019: 9).

In platform work, the power of algorithmic evaluation and discipline has likewise been found to contribute to high work intensity and long work hours. Wood et al. (2019) find that remote platform workers fear that missing tight deadlines will result in damaging customer ratings and thus work long intense hours often without breaks – many experience pain as a result. However, in this sector at least, algorithmic evaluation and discipline have also been found to be associated with experiences of autonomy. This is a result of customer ratings being collected at the end of the labour process, and thus not impinging on workers’ discretion over how they do their job (Wood et al. 2019). As one worker explained:

‘I don’t have someone supervising, telling you: “you have not done this, you have not done this,” yelling at you’ (Wood et al., 2019: 9).

Wood and Lehdonvirta (in press) term the contradictory process of experiencing autonomy despite dependency on platforms that shape work experiences ‘subordinated agency’. However, findings from warehouses and manufacturing highlight how algorithmic instruction restricts discretion (Briône, 2020; Bloodworth, 2018; Delfanti, 2019; Gent, 2018). Moreover, Wood and Lehdonvirta (2021) also document that the algorithmic empowering of customers through inherently capricious and opaque rating systems generate intense feelings of insecurity among workers. The opacity of algorithmic management can also lead to informational asymmetries (Veen, 2020; Gregory, 2020; Rosenblat and Stark, 2016; Shapiro, 2018), weak remedies to unfair treatment (Wood and Lehdonvirta, in press; 2021), and the denial procedural due process in the workplace (Kellogg et al., 2020). That algorithmic management has been found to result in highly intense and insecure work might explain the finding of Berger et al. (2019) that UK Uber drivers experience elevated levels of anxiety. Likewise, Orlikowski and Scott (2014: 886) report that the constant surveillance that hotel

workers face from customer ratings means there ‘is no opportunity for recovery, they are ever anxious.’

A final consequence of algorithmic management is that the insecurity, routinisation, and intense working it can give rise to may provoke acts of worker resistance. For instance, Uber drivers have been found to resist the algorithmic allocation of work by turning off their driver mode when in bad neighbourhoods, staying in residential areas to avoid bar patrons, and frequently logging off to avoid long trips (Lee et al. 2015). Wood et al. (2019) find that remote platform workers learn to circumvent the automated monitoring of their work by learning when screenshots of their desktop will be taken and using secondary monitors. Journalists too have resisted algorithmic evaluation of their work by manipulating the variables they enter into evaluation systems so as to obtain the score that they desired (Christin, 2017). Likewise, legal professionals and police officers have been documented to obscure the algorithmic evaluation of their work by blocking data collection or by producing more data (Brayne and Christin, 2020).

4 Discussion and policy implications

The above literature has highlighted algorithmic management as being central to digital labour platforms. It has also shown that the scope for digital data collection in conventional employment settings has expanded in recent years, and as a consequence, the use of software algorithms to manage workforces in such settings is also growing. Research and news reports have noted the significant use of algorithmic management in logistics (both in warehouse and delivery work) and to a lesser degree similar technologies have been noted in retail, manufacturing, marketing, consultancy, banking, hotels, call centres, and among journalists, lawyers and the police. Algorithmic management has been defined as ‘software algorithms that assume managerial functions’ (Lee et al., 2015: 1603). While algorithmic management has the potential to displace the need for low-level managers, at present, beyond the gig economy, it seems to rather represent a transformation of the role of human managers. Curtailing the scope for decision making of low-level managers and supervisors and confining their organisational function to offering workers encouragement and support in navigating the algorithmic direction and evaluation, and disciplining workers automatically flagged by these systems for non-compliance or poor performance. As Briken and Taylor (2018: 453) put it, ‘management consists of executing decisions based on data analytics’. In part, the continued role of human managers may result from legislative rather than technical requirements. For instance, article 22 of the GDPR states the ‘data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her.’ Therefore, algorithmic management that entails fully automated decision-making that has significant effects on individuals without input from human managers would be illegal in the EU and the UK. Importantly, human input needs to be ‘meaningful’ and not just the rubber-stamping of an algorithmically determined outcome for a decision not to be classed as automated (Binns and Gallo, 2019a). According to the UK’s Information Commissioner’s Office and European Data Protection Board:

- Human reviewers must be involved in checking the system’s recommendation and should not “routinely” apply the automated recommendation to an individual;
- reviewers’ involvement must be active and not just a token gesture. They should have actual “meaningful” influence on the decision, including the “authority and competence” to go against the recommendation;
- and reviewers must ‘weigh-up’ and ‘interpret’ the recommendation, consider all available input data, and also take into account other additional factors’ (Binns and Gallo, 2019b).

Therefore, algorithmic management in its ideal typical-form, in which algorithms completely assume managerial functions and act autonomously, may, in reality, be rare not only due to technical difficulty of creating systems that can account for the full range of tasks, uncertainty and contingency that human managers deal with, but also because these systems would contravene EU and

UK law. However, what constitutes an automated workplace decision in practice is disputed and currently the subject of a legal challenge by Uber drivers (Bernal, 2020; Moss, 2020). Therefore, even where technically feasible, algorithmic management is more likely to take the form of a systematic and integrated assemblage of human and algorithmic actants for both legal and efficiency reasons. This raises the question of whether direction, evaluation, and discipline were truly automated in the examples discussed in Section 2 and the degree to which they differ from more conventional uses of software by management to inform decision-making.

One potential means for better understanding this inherently blurry, disputed, and legally thorny issue is to draw on understandings of automation developed from studies of autonomous vehicles. In particular, the Society of Automotive Engineers (SAE) (2014) have produced an automation classification to aid the definition of self-driving vehicles. In Figure 1 the SAE classification has been adapted for application to algorithmic management in the workplace.

Figure 1: Classification of automation in algorithmic management, adapted from the Society of Automotive Engineers' 2014 classification of self-driving vehicles

Level of automation	Narrative definition	Direction, Evaluation, Discipline	Review (in case of system failure)	Mode specific (human manager can ignore/overrule system)
No automation	Full-time performance by <i>human manager</i> of all aspects of direction, evaluation and discipline	Human manager	Human manager	n/a
Management Assistance	Assistance in either direction, evaluation or discipline with the expectation that <i>human managers</i> perform other management tasks and use own judgement to review, ignore and overrule system.	Human manager and algorithmic system	Human manager	Yes
Partial Automation	Mode specific execution of either direction, evaluation or discipline with the expectation that <i>human managers</i> perform remaining functions.	Algorithmic system or human manager	Human manager	Yes
Algorithmic management				
Conditional Automation	Mode specific execution of direction, evaluation and discipline with the expectation that <i>human managers</i> will respond appropriately to a request to intervene.	Algorithmic system	Human manager	Yes
High Automation	Full-time performance by an algorithmic system of direction, evaluation and discipline without the need for <i>human managers</i> to intervene.	Algorithmic system	Algorithmic system	Yes
Full Automation	Full-time performance by an algorithmic system of direction, evaluation and discipline without the possibility for <i>human managers</i> to intervene.	Algorithmic system	Algorithmic system	No

This original framework enables us to understand the difference between the algorithmic assistance in direction, evaluation, and discipline and the partial automation of management. Algorithmic assistance and partial automation differ in that the former requires managers to continuously use their own judgement to review, ignore and overrule the system, whereas the latter functions without the need for human input unless a manager chooses to intervene. This framework also highlights that the difference between the partial automation of managerial functions and algorithmic management is that algorithmic management entails automated systems that simultaneously direct, evaluate and discipline the workforce; limiting the role of managers in these areas to responding appropriately to system requests for intervention. However, the framework also distinguishes between conditional and highly automated algorithmic management in that the latter type of system can act without needing human managers to intervene. The final distinction made by this framework is the delineation of full automation under which it would be impossible for a human manager to intervene in an algorithmic decision even if they wanted to. This full automation category exists as an ideal type of algorithmic management but remains a long way from realisation, and may, in fact, never be practical – at least without the advent of artificial general intelligence.

In practice, algorithmic management entails workers accepting tasks and schedules automatically assigned to them; direction in how they carry out their work by computer software that also dictates the timeframe that they have to complete it. It also involves the real-time and continuous evaluation of work performance generated from data points such as customer satisfaction ratings and behavioural, emotional and biological metrics. Algorithms that flag-up workers' performance to managers in real-time or automatically restrict access to future assignments or hours. The algorithmic evaluation of workers may even take place before a worker is hired with predictive analytics used to sort candidates according to work history, identification information, schedule availability, background checks, and personality and skill assessments. Importantly, according to the above classification, such systems would still constitute 'conditional' algorithmic management if they require a human manager to respond to the system when requested and who can ignore or overrule the system when they believe it has failed or not functioned optimally.

Applying this framework to the examples discussed in Section 2 highlights that while there exists a wide range of algorithmic systems that partially automate management and go beyond mere managerial assistance, algorithmic management has, nevertheless, only been fully implemented in driving and delivery platform work by firms such as Uber, UberEATS, Deliveroo and Foodora, as well as logistics firms, such as Amazon. In the logistics sector, algorithmic management seems to most closely approximate conditional automation, as algorithmic systems request intervention by human managers at critical moments in the management of warehouses and delivery fleets, and this input by humans is needed for the system to function. Digital labour platforms such as Uber, UberEATS, Deliveroo, Foodora, on the other hand, arguably, more closely approximate high automation in that these systems do not seemingly require intervention by human managers – although it is possible for managers to review and overrule algorithmic decisions where they are deemed incorrect or suboptimal. Even in this sector firms continue to employ managers who review algorithmic decisions and can overrule automated systems when issues emerge (however these systems are seemingly not designed with a need for human input for them to function normally).

The above literature suggests that the consequences of algorithmic management for some workers will include the reduction of discretion in choosing how to undertake their job as well as limited discretion over the ordering of their day-to-day tasks. However, as detailed above research on platform work suggests that even reduced formal autonomy can be experienced as enhanced labour process autonomy due to the absence of direct human managers and supervisors overseeing the labour process (Wood et al., 2019). The algorithmic direction of work may also reduce intrinsic skill use and disincentivise firm investment in skills. Technical change has widely been assumed to be skill-biased in that digitalisation enhances the productivity of skilled workers (cf. Fernández-Macías and Hurley, 2017). However, research has highlighted a weakening demand for cognitive skills in recent years (Henseke et al., 2018). Additionally, by reducing the costs of replacing workers, algorithmic management may increase the use of fissured employment relations, such as temporary agency workers and self-employed workers. The use of algorithmic scheduling systems heightens the use of precarious, short shifts and unstable and unpredictable schedules (Wood, 2020). Algorithmic direction, evaluation, and discipline intensify work effort by increasing monitoring, raising the pace required of workers, minimising gaps in workflow, and extending work activity beyond the conventional workplace and working day. Finally, the use of capricious and opaque algorithms to make managerial decisions creates feelings of insecurity among workers and may lead to unfair treatment and the denial of procedural due process in the workplace. The limited learning at work and influence over tasks, work intensification and insecurity highlighted above is likely to increase workforce stress and anxiety and be harmful to wellbeing and health. At the same time, the harms experienced by workers can provoke new forms of resistance as individuals attempt to circumvent, game and manipulate algorithmic management.

In light of the above consequences for workers, algorithmic management clearly has important policy implications. Discussions of policy related to algorithmic management has often focused on one of three areas: that the use of data and digital technologies will a) lead to aggregate job losses through automation, b) transform jobs and therefore require workers to develop new skills (Spencer

et al., 2021), or c) undermine individual privacy and equality rights (Dencik, 2021). However, the above review of empirical literature highlights that while algorithmic management has the potential to displace the need for low-level managers and supervisors, and platform work provides an example of this potential, at present, it instead seems to constitute a more general transformation of managerial job roles. Likewise, Spencer et al. (2021: 43) summarise that ‘the general academic consensus... is that apocalyptic predictions of mass job loss or the end of work are largely unfounded, although the likely impact of digital automation on the restructuring of work is likely to be profound and multifaceted.’ In the case of algorithmic management, this restructuring of work seems likely to entail the reduced scope for discretion and intrinsic skill use for both managers and workers alike. It has also been found to increase the intensity of work and lead to greater insecurity – resulting in stress, anxiety, and lowered wellbeing and health and potentially sparking new forms of worker resistance. In this context a focus on aggregate employment levels, supply-side skills provision, and individual equality and data rights, while necessary, are inadequate remedies.

As noted above, the GDPR was adopted by the EU in 2018, and has some bearing on algorithmic management as its provisions include the right not to be subject to a decision based solely on automated processing that significantly affects them (Aloisi and Gramano 2019; Sánchez-Monedero et al., 2020). Despite the workplace being excluded from this regulation in its final stages (Colclough 2020) it still offers workers, as individual citizens, the above right (Dencik, 2021). In fact, four UK workers are currently suing Uber over alleged automated firing by the platform – however, Uber maintains their accounts were reviewed by a human before being deactivated (Moss, 2020). Given that the literature reviewed above highlights that algorithmic management redefines the role of human managers as ‘executing decisions based on data analytics’ (Briken and Taylor, 2018: 453), GDPR is likely to offer only a limited remedy against the potential harms highlighted above (see also Aloisi and Gramano 2019; Dencik, 2021). Indeed, UK and EU equality and data rights laws seem to have little influence on the design of automated hiring systems (Sánchez-Monedero et al., 2020).

An alternative approach advocated by De Stefano (2018) and Dencik (2021) is the development of collective rights that protect workers from algorithmic management. De Stefano (2018) builds upon a European Economic and Social Council Opinion in arguing for a ‘human-in-command’ principle in which workers would be involved in the implementation of algorithmic management to ensure they retain autonomy and control, self-fulfilment, and job satisfaction (see also Spencer et al., 2021). Such an approach could potentially increase accountability and reduce the likelihood of discrimination (Spencer et al., 2021). De Stefano maintains that not only should algorithmic decisions be reviewed by legally accountable human managers but that sectoral and workplace collective bargaining have a central role in enabling ‘human-in-command’ algorithmic management practices. Therefore, De Stefano (2018: 24) argues that “negotiating the algorithm” could become a crucial objective of social dialogue and action for employers’ and workers’ organisations. Indeed, Moore et al. (2018) highlight several collective agreements that regulate the use of digital technologies to monitor and direct workers. Additionally, some unions have pushed for ‘new technology agreements’ as part of their collective bargaining strategies. These agreements would require employers to gain the agreement of a union before implementing new technologies and to pass on productivity gains through investment in jobs (Dencik, 2021; Spencer et al., 2021). For example, Swedish co-determination laws require employers to consult with trade unions before any major change in the workplace that will impact employment and working conditions and enable unions to veto plans to outsource work. Comparative studies of job quality highlight that the resultant workplace power combined with workers’ strong market power (from extensive trade union membership, collective bargaining and rights to engage in collective action) leads Swedish workers to experience relatively high rates of job control and representational influence and thus fewer high strain jobs (Gallie and Ying 2013) as well as less precarious conditions (O’Brady, 2021).

However, in many countries, trade union membership and recognition are low, especially in the private sector. Therefore, when trade unions are absent or limited in their coverage, agreement and consultation could instead be required with works councils before new technologies are implement-

ed. Interestingly, in France employee representatives (works council and health and safety committee) must be consulted before implementing any system that monitors employees' activities (Aloisi and Gramano 2019). Spencer et al. (2021: 53) build on Piketty (2020) to suggest two further ways to 'offer a voice for workers and... ensure democratic accountability in the innovation process': require employees to have 50 percent of the seats on company boards and that the voting power of all shareholders be capped at 10 percent. Spencer et al. (2021) go on to suggest a number of further new collective rights that could reduce the harms of algorithmic management identified above. These include a requirement 'for firms to report on the impacts of digital technologies on jobs, wages and the quality of work' (Spencer et al. (2021: 54). Noting that digital technologies can boost productivity but that some technologies, such as the algorithmic management reviewed above 'may be an increase in the intensity and duration of work time' Spencer et al. (2021; 53) also suggest a policy that the legal working week be reduced to 38-hours per week. Taken together, co-determination laws that cover the adoption of algorithmic management and afford unions and work councils consultation and veto rights along with new rights to a shorter working week could help reduce the negative impacts of algorithmic management on discretion, intrinsic skill, work intensity and insecurity; thus making its introduction into workplaces less stressful and anxiety-inducing for workers and ensuring healthy, happy and harmonious future workplaces.

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