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The Algorithmic Management of Work and its Implications in Different Contexts

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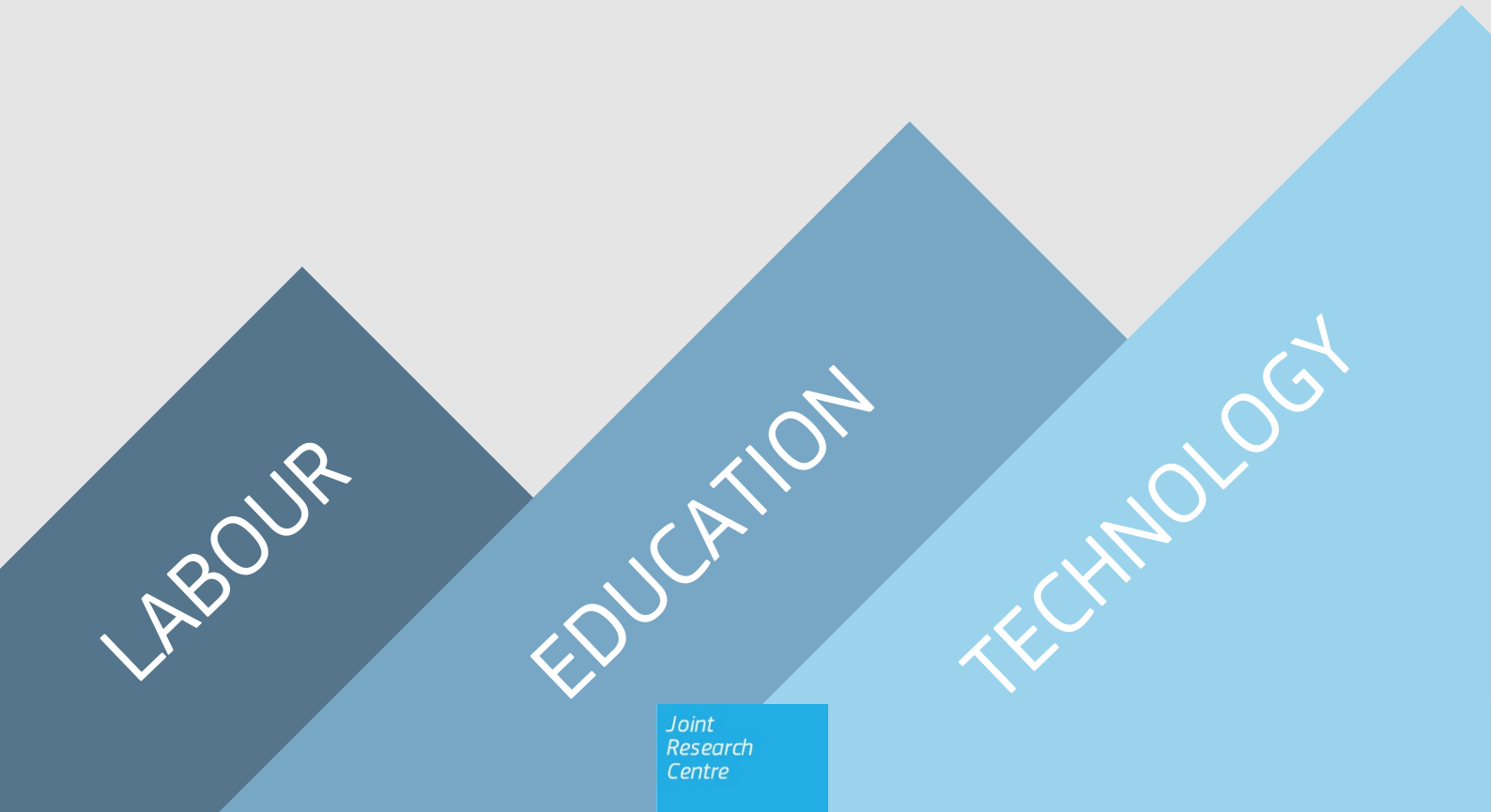

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The Algorithmic Management of work and its implications in different contexts

Sara Baiocco (JRC), Enrique Fernández-Macías (JRC), Uma Rani (ILO) and Annarosa Pesole (JRC)[1]

Abstract

This paper provides a conceptual framework for the emerging phenomenon of algorithmic management and outlines some of the implications for work, from work organisation to working conditions (job quality). The paper defines algorithmic management as the use of computer-programmed procedures for the coordination of labour input in an organisation and puts it into context to discuss its usage in both digital labour platforms and 'regular' workplaces and companies, exploring its implications and providing a few policy suggestions. The paper argues that while algorithmic management should be understood as the digital evolution of certain pre-existing trends that have long characterised the organisation of economic activity, it is potentially disruptive. This is because it increases considerably the organisational ability of controlling complex economic and work processes, as it benefits from the massive capacity to collect, store and process information of digital technologies. In algorithmic management, these technological developments are combined and used for re-organising control and re-shaping power balances in the workplace. This paper contributes to the growing academic and policy literature on algorithmic management, proposing a conceptual framework for empirical investigations and a basic compass for policy making in this area.

Keywords: Algorithmic management, digitalisation, automation, digital labour platforms, work organization, working conditions.

[1] The views expressed in this working paper are those of the authors and do not necessarily represent the views of the organisations where the researchers are based.

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Executive summary

This paper proposes a **comprehensive framework** to investigate and discuss **algorithmic management, from definition to policy options**.

First, the paper provides a **definition of algorithmic management** that can help identify it in different work contexts. Its key elements are the algorithms to process data, and the purpose to coordinate work. Along with this definition, the paper discusses the management functions that algorithms can undertake and the degree of automation that algorithmic management can reach, highlighting that the full automation of management is impossible in regular workplaces. It also underlines how algorithmic management has many aspects in common with other pre-existing ways to organise economic activity, such as bureaucracy and scientific management, and discusses its practical applications in different work contexts.

Second, the paper stresses the **centrality of data for algorithmic management systems** in digital labour platforms, which is the most advanced and developed, providing a comprehensive overview of how algorithms undertake different management functions (planning, staffing, commanding, coordinating and controlling) on these platforms. Based on a large body of empirical evidence, it discusses how the algorithms for these management functions in digital labour platforms have implications on both work organisation and job quality.

Third, the paper explores the **use of algorithmic management in regular workplaces**. There, algorithms can perform similar functions to a more moderate extent (or at least less documented) than in digital labour platforms, but the new practices interact and thus change pre-existing features of the organisations that introduce algorithmic management systems. Focusing on the implications for work organisation, it explains that algorithmic management tends to centralise knowledge and control, redefine roles and tasks of workers and blurs the boundaries of the organisation. It then discusses how these changes in work organisation affect working conditions and several aspects of job quality. It also highlights the need to further build empirical evidence in regular work settings and the pivotal role of organisational choices and policies to determine the final outcomes for workers.

Finally, the paper sketches some **policy options to confront the potentially negative effects of algorithmic management**, and to rebalance the equilibrium between employers and workers in the digital age. First, a comprehensive regulatory framework could offset the centralisation of power and control, by establishing workers' rights on the use of their data and in terms of accessibility to algorithms' criteria and functioning. Second, the creation of participatory mechanisms and bodies to negotiate and monitor the algorithmic management so as to prevent abusive applications against labour and fundamental rights, to ensure that its benefits are shared equitably.

Future research and policy on algorithmic management requires a better understanding of the phenomenon as a whole, departing from the distinction between digital labour platform and regular workplace settings and focusing on the key elements of algorithmic management, namely the functioning of algorithms to process data, the data itself, and its implications for work regardless of the work setting. Given the current bias of algorithmic management literature towards digital labour platforms, research gaps need to be filled when it comes to the implications of algorithmic management in regular work settings. In regular workplaces, the outcomes of algorithmic management in terms of working conditions and job quality will depend crucially on its interaction with those pre-existing organisational practices and institutional features.

Contents

1 Introduction

The debate on the implications of the digital transformation for work and employment has tended to focus on the impact of automation on jobs, both in terms of overall employment and in terms of occupational structure and skills demand (Fernández-Macías et al., 2021). Yet, the most obvious and direct impact of the digital transformation concerns the data that digital technologies can generate, collect, store, process, transfer and communicate. As such, this transformation does not only impact on the amount (i.e. overall employment) and type (i.e. occupations and skills) of work to be done by humans (now and in the future), but perhaps even more importantly on how such work is undertaken, coordinated, monitored and evaluated. Wherever digital technologies allow to collect and process data for the coordination of work, some form of algorithmic management is likely to be deployed in ways that will significantly affect work organisation and job quality.

Although algorithmic management is a new thing, if we look closely at its underlying mechanisms, it appears as a continuation of very long historical trends of rationalisation or bureaucratisation of economic activity and the organisation of work. In effect, it can be seen as an derivative form of scientific management, which was already (at least partially) digitised in some of its recent incarnations such as Just-in-Time production or lean manufacturing. The increasingly pervasive use of digital technologies across all economic activities and the availability of massive amounts of data makes algorithmic management potentially disruptive for the future of work (Kellogg et al., 2020). It should be emphasized that algorithmic management relies on digital technologies and data, but always entails organisational and institutional choices on the specific use of those technologies for work coordination purposes. As a socio-technical process (Jarrahi et al., 2021), algorithmic management is shaped by socio-institutional and organisational factors, which contribute to its development and outcomes.

The characteristics and implications of algorithmic management have been discussed so far mainly in the context of digital labour platforms. However, the increasing digitisation of the economy, which has been accelerated by the Covid-19 pandemic, has led to the extension of algorithmic management practices in more traditional working environments, such as factories, offices, hotels, retail and wholesale warehouses. It is important to understand how the novel aspects of algorithmic management interact with pre-existing organisational structures and features. The evidence already accumulated on the nature and implications of algorithmic management in the context of digital labour platforms certainly provides a useful starting point for a broader understanding of this phenomenon, but it should be complemented with new research on how algorithmic management is being used beyond digital platforms, to provide a more comprehensive picture.

The purpose of this paper is to lay down a conceptual framework to study algorithmic management, considering its application in different work contexts, namely digital labour platforms and regular work settings. The remainder of the paper is as follows. Section 2 introduces our definition of algorithmic management, while also discussing key related concepts and historical precedents. Section 3 reviews the evidence on algorithmic management in digital labour platforms and stresses the importance of data for this form of management, while Section 4 provides a framework to map the effects of algorithmic management in regular workplaces, from work organisation to job quality. Building on the empirical evidence and issues elaborated in the earlier sections, Section 5 discusses some policy options to facilitate the regulation of algorithmic management as it spreads to the wider economy.

2 Defining and contextualising algorithmic management

2.1 What is algorithmic management?

Algorithmic management can be defined as the use of computer-programmed procedures for the coordination of labour input in an organisation.[2] There are two components in this definition.

On the one hand, an *algorithm* is a set of predefined rules to be followed in sequence to solve a problem. Algorithms have been used for centuries for all kinds of problems that are susceptible to standardisation and encoding, from cooking recipes to bureaucratic procedures (Barbin et al., 2012). However, when speaking about algorithmic management we refer to algorithms which are digitally encoded and implemented by computers, and which process data. Since the digital revolution, the capacity of computers to process numeric data has increased by several orders of magnitude, in terms of speed, efficiency and complexity. Thus, an increasing range of real-world problems (in particular, those that can be numerically encoded in an unambiguous way) can be potentially solved using computer algorithms. Management may be one of them, hence the concept of *algorithmic management*.

On the other hand, *management* is a set of tasks which are necessary for the administration of an organisation. These tasks are normally implemented by a specialised position which is at the top of the organisational hierarchy: the manager(s). This paper is particularly concerned with the managerial tasks that relate directly to the coordination of labour input within the organisation, and which Henri Fayol (2016, originally 1916) summarised in five functions: planning (i.e. deciding in advance), staffing, commanding, coordinating and controlling. With algorithmic management, all these functions can be supported or at least partly implemented with computer algorithms, if the associated managerial problems can be numerically encoded in a more or less unambiguous way. The algorithmic staffing is typically conducted using databases of prospective or current employees, whereas the functions of commanding, coordinating and controlling can be algorithmically implemented via digital devices that collect, process and communicate real-time information to and from the worker according to algorithmic rules specified by management. Of the five management functions described by Fayol, planning is the hardest to automate because it implies setting strategies and rules for deciding in advance, which algorithms cannot do on their own.[3] This function can be supported by algorithms too but the degree to which these functions can be automated can vary across different work contexts (see Box 1).

Box 1: The level of automation of algorithmic management systems

Wood (2021) proposes a classification of algorithmic management based on the levels of automation when implementing management functions, as shown in Figure 1. Although this classification is analytically useful, its practical applicability is limited for the following reasons.

First, the "full automation" category is technically impossible unless we are referring to a general artificial intelligence system (or strong AI) which could function in an entirely autonomous way (which only exists in science fiction). In fact, even the category of "high automation" in Figure 1 (an automated system of direction, evaluation and discipline which does not need human managers to

[2] This can have an impact on job descriptions, monitoring of work and performance evaluation, as we will discuss later.

[3] It is interesting to note that the function of planning in management is analogous to the *design* of algorithms, as both imply setting strategies and rules for deciding in advance. Ultimately, the design of algorithms is the hardest task to automate: if algorithms can design themselves in a strict sense (without any human input), we would be speaking about some kind of general artificial intelligence that can function in a completely autonomous way. As of today, that type of artificial intelligence only exists in science fiction. Currently existing AI is instead “narrow” (rather than “general”) and requires human input for specifying the broad parameters and goals (and to feed the data) that the AI system will use to generate semi-automated algorithms.

intervene) cannot exist in practice. Even the most advanced models of algorithmic management, such as those used in digital labour platforms, still require intensive human intervention for the design, maintenance, and troubleshooting of the algorithms, and for dealing with exceptional cases or unforeseen situations. Thus, in practice even the most highly automated forms of algorithmic management are cases of "conditional automation", where algorithms deal with a number of predefined situations with interventions of human managers when necessary.

Second, even in the case of digital labour platforms, the distinction between the categories of "partial" and "conditional" automation is in fact very difficult to make. In practice, the automation of management is in the majority of cases simultaneously "partial" and "conditional". There are always necessarily some managerial tasks and functions that cannot be automated (not even conditionally), as for instance the tasks related to setting up strategies and rules for the algorithms themselves, as discussed earlier. Therefore, all forms of algorithmic management are both "partial" and "conditional". This means that in practice, the 6 levels of automation proposed by Wood (2021) could be collapsed into three, as shown in Figure 1: "no automation" (with fully human management), "assistance" (using algorithms to assist human managers in their decisions) and "partial-conditional automation" (using algorithms to make some decisions, with human managers retaining some key functions and intervening when necessary). A fourth purely theoretical category of "full automation" can be added for analytical purposes, if it is clear that it has no real application.

Third, even taking into account the previous considerations, the level of automation of algorithmic management systems has limited practical relevance unless these systems become more transparent. Since algorithmic management systems tend to be both opaque and under the control of (human) management, managers can simply use them to increase their ability to take arbitrary decisions concerning workers, without consulting or discussing them. Without some degree of transparency, it can be even impossible to tell whether a particular decision has been made by an algorithm or a human boss (and very difficult to contest such a decision).

Figure 1: Classification of levels of automation in algorithmic management

(Original proposal by Alex Wood, 2021)					*(Alternative proposal)*	
Level of automation	**Narrative definition**	**Direction Evaluation Discipline**	**Review (in case of system failure)**	**Human can overrule system**	**Alternative levels of automation**	**Comments**
1. No automation	Full-time performance by human manager of all aspects of direction, evaluation and discipline	Human manager	Human manager	n/a	**1. No automation**	Same as in Wood 2021
2. Mgmt. assistance	Assistance in either direction, evaluation or discipline with the expectation that human managers perform other management tasks and use own judgement to review, ignore and overrule system	Human manager and algorithm	Human manager	Yes	**2. Mgmt. assistance**	Same as in Wood 2021. Algorithms assist human managers in their decisions
3. Partial automation	Mode specific execution of either direction, evaluation or discipline with the expectation that human managers perform remaining functions	Human manager or algorithm	Human manager	Yes	**3. Partial <u>and</u> conditional automation**	Algorithms make some managerial decisions, with human managers retaining key functions and intervening when necessary
Algorithmic management						
4. Conditional automation	Mode specific execution of direction, evaluation and discipline with the expectation that human managers will respond appropriately to a request to intervene	Algorithm	Human manager	Yes		
5. High automation	Full-time performance by an algorithmic system of direction, evaluation and	Algorithm	Algorithm	Yes	*4. Full automation*	*Same as in Wood 2021, but*

	discipline without the need for human managers to intervene					*purely theoretical, no real application until the arrival of general artificial intelligence*
6. Full automation	Full-time performance by an algorithmic system of direction, evaluation and discipline without the possibility for human managers to intervene	Algorithm	Algorithm	No		

Source: Elaborated from Wood (2021: 12) and authors´ compilation
Note: The classification is adapted from the 2014 Classification of self-driving vehicles developed by the Society of Automotive Engineers. The management functions are grouped, in Wood's (2021) approach, into three main categories, namely direction, evaluation and discipline, which can be seen as a consistent simplification of the Fayol's model adopted in this paper.

Algorithmic management should be understood in the context of the impact of the digital revolution on work and employment. The digital revolution, as discussed earlier, is driven by the expansion in the capacity to store, process and communicate information using electronic devices, cloud services and cloud infrastructure (ILO, 2021; Eurofound, 2018a). The first three or four decades of technological revolution since the 1970s correspond to the installation phase of the digital technologies, a period marked by fast innovation, big investments, new infrastructures and rapid diffusion of new technologies and skills. This period ended abruptly in early 2000s with a series of financial crises (culminating in the Great Recession of 2008) as expected (Pérez, 2003; Freeman and Louçã, 2001), giving way to a deployment phase which is still ongoing.

Rather than a technical innovation, algorithmic management consists of a new combination of existing (and widely available) technologies with potential for disrupting existing economic practices. Algorithmic management is associated with many key digital technologies: big data analytics, machine learning, geolocation, connected mobile devices, wearables, etc. It should be understood as a specific way of combining and using those technologies to automate or at least support some of the functions previously carried out by human management for the coordination of work. In this sense, algorithmic management is a socio-technical process (Jarrahi et al., 2021), always entailing a technical side (i.e. the technologies available and adopted) and a social or organisational side (i.e. the ways those technologies are used and the institutional and organisation context in which they are adopted).

In a recent paper, Eurofound (2018a) argued that the digital revolution affects work and employment through three vectors of change, namely *digitisation*, *automation* and *platformisation*. Each of these vectors is associated with specific combinations of digital technologies that alter the way work is performed and organised. Although algorithmic management is particularly associated with one of those vectors (i.e. platformisation), it is linked to all of them, as discussed below.

Digitisation of work refers to the use of sensors and rendering devices to translate (parts of) the physical production process into digital information (and vice versa). In many ways, this is the core material transformation behind the digital revolution: the growing digitisation of everything allows benefitting from the increased possibilities of data processing, connectivity, storage, etc. But digitisation is mostly about the increasing availability and usability of information. Especially in contexts where the collection and use of data can be centralised, as in economic organisations, this raises serious concerns in terms of privacy and control, as examined in later sections. In practice, some degree of digitisation of the labour process is necessary for algorithmic management to exist: for computer algorithms to be able to direct, evaluate and discipline workers, they have to be fed some digital data on those workers, ideally in real time. Indeed, algorithms would be a void sequence of rules and orders without the data feeding them, with no consequence or value for management purposes. But the importance of data in this process goes beyond the practical reason of needing information to get a valuable output. Data quality and data availability are often intertwined with the design of the set of rules that will codify the algorithms and constitute an integrated part of the algorithmic management process. This is evident when algorithmic management is supported by artificial intelligence tools that allow for autonomous learning and correcting. In fact, a key part of

the value added of using algorithms for work organisation is to harness the power of the data to extract the maximum value in line with the goal stated by the general rule. As a hypothesis, we can say that *digitisation (of work) tends to favour algorithmic management*, because the more data is collected on a productive process, the easiest and more efficient it will be to control it algorithmically, as well as for workplace management and organisation.

Automation of work refers to the replacement of labour input by (relatively autonomous) machine input for the performance of some types of tasks in production and distribution processes. The link between the concepts of automation and algorithmic management is that the latter may imply some degree of automation of management. In other words, algorithmic management involves the replacement of labour input by machine (algorithmic) input for some types of managerial tasks. If algorithms only assist human managers in their decision-making, strictly speaking there would be no automation of management, but the process still qualifies as algorithmic management, as stressed above. It should also be noted that any process of automation of production or service delivery can facilitate the adoption of algorithmic management. First, because it drives standardisation, which is a key feature of algorithmic management too. Second, because it fosters the use of machines that, when digitally driven (i.e. when automation is coupled with digitisation), can be more easily interconnected to and included within algorithmic management systems.

Platformisation of work refers to the use of digital platforms (e.g. in the form of apps, webs or any similar digital system) to coordinate work processes in any kind of organisation.[4] This concept is the closest to algorithmic management. In many cases, it can be considered as its synonym, although there are some differences. The concept of platformisation of work emphasises the existence of a digital space or network (i.e. the platform itself) where labour transactions take place, with algorithmic management being used for the coordination of those transactions. In all digital platforms for coordinating work transactions, there will be some algorithmic management embedded. And, in most instances of algorithmic management, there will be some type of digital platform where the transactions are being coordinated. But the concept of algorithmic management puts the focus on the algorithms themselves and on the data that feed them, rather than on the medium or space used for the coordination. In theory, there could be algorithmic management without a digital platform: for instance, if digital information (i.e. data) on the labour process is directly collected and inputted into computer algorithms that managers use and communicate to workers.

In practice, the three vectors of change (*automation*, *digitisation* and *platformisation*) tend to go together as the digital revolution spreads throughout economic organisations, and they all tend to be linked with algorithmic management. To benefit from the possibilities of improved intelligence and communication afforded by digital technologies, companies are increasingly digitising their productive processes. As more and more processes are digitised, the use of algorithms for coordinating those processes becomes both easier and more efficient. And as those forms of coordinating work and economic processes become more efficient, there will be (at least in theory) increasing possibilities for the automation of some types of tasks within the process, including managerial functions, by applying algorithmic management.

2.2 What is new about algorithmic management?

Many of the key features of algorithmic management have existed for a very long time, well before the digital revolution. When removing the *digital* component from the definition of algorithmic management, it could be argued that there have been historical precedents of this system for centuries or even millennia. Bureaucracy and scientific management are two of these historical precedents that can be considered as forms of 'non-digital algorithmic management'.

[4] In this paper, digital platforms are defined as online services that provide a digital environment where interactions can take place.

A bureaucracy is a form of organisation defined by Max Weber (2015, originally 1922) by the following features: a well-defined hierarchy, specialisation of labour and selection based on qualifications, formal rules and regulations, and impersonality in the application of rules. The last two elements in particular (formal rules and impersonality in their application) are the ones that directly connect all forms of bureaucracy with algorithmic management. As argued by Weber, the history of human civilization can be understood as a process of increasing bureaucratization, with more and more activities (e.g. governments, armies, companies) being organised bureaucratically and with a continuous deepening of each of its constituent elements (i.e. hierarchy, specialisation, rules and impersonality). Weber thought that this process was inexorable because bureaucracy is the most efficient and rational form of organising human activity, but he was also concerned about it. In his view, it could lead to the increasing asphyxiation of human freedom within an iron cage of rational control based on encoded rules impersonally implemented. The Kafkian nightmare of powerless individuals trapped by bureaucratic mechanisms based on rules that they cannot even understand is a good representation of Weber´s concerns.

Potentially, computer-based algorithmic management can be the culmination of Weber´s bureaucratisation process - and of his fears too. In algorithmic management, the rules have to be so unambiguously encoded as to be feasible to implement them in an automatic (algorithmic) way: all decisions taken this way are by definition impersonal. But as has been often noted in recent critiques of algorithmic management from an ethical perspective, impersonal does not mean fair. The rules themselves can be biased and unfair, and thus the decisions taken by algorithmic systems will be biased and unfair no matter how impersonally they are implemented. An additional problem of algorithmic management from this perspective is the increasing use of artificial intelligence for decision making: those technologies allow the computer to take decisions that maximise some parameters specified by humans, but the specific rules for making those decisions can be partially inferred by the computer itself from data fed to it. In other words, at least potentially these systems allow to shift human intervention to a higher level of abstraction, specifying broad goals and strategies which the computer will transform into rules for decision-making which will be algorithmically implemented. The specific rules themselves can be unknown even to those that run the algorithmic management system, not to mention the workers affected by them. In terms of accountability and transparency in management decisions, this is a dystopian possibility that comes as close to Weber´s iron cage fears as can be.

But algorithmic management also differs from traditional bureaucracy in some important ways. A key element of Weber's definition of bureaucracy is the existence of a hierarchy of management levels, whereas algorithmic management tends to do away with low and middle management functions because the algorithms themselves can implement the rules. In an extreme case of algorithmic management, only the top level of management would be necessary to design the rules to be implemented. Thus, in some ways, algorithmic management could both culminate and transcend the bureaucratisation process.

Scientific management (or Taylorism) is another important precedent of algorithmic management. Scientific management is the theory of management pioneered by F.W. Taylor, who proposed a radical reorganisation of production in factories on the basis of a rational, detailed and systematic analysis of tasks, a standardisation of processes, a (more) detailed division of labour, and the centralisation of productive knowledge and power in the hands of management (Braverman, 1974). Scientific management is part of the same rationalisation process that gave rise to bureaucracy, and both organisational systems have similarities. For instance, both rely on strong hierarchies, detailed division of labour and formalisation of processes. But at least from a Weberian perspective, bureaucracy is essentially about efficiency in organising cooperative human activity, whereas scientific management as proposed by Taylor was explicitly aimed at reconfiguring and centralising

the distribution of power and control in production, away from workers and into the hands of management.[5]

There are also obvious connections between scientific and algorithmic management. First, for it to be effective, algorithmic management requires a degree of standardisation and rationalisation of tasks similar to that proposed by Taylor, as we will discuss in Section 4. Indeed, the use of algorithmic systems of management is often linked to what has been called "digital Taylorism" (Gautié, Jaehrling and Perez, 2020). This consists in the reorganization of work processes that up to recently were too complex to be organized along Tayloristic principles (mostly in services), pursued by using digital devices to split and standardize tasks, and algorithmic management to centralise control and decision making. Second, the decisions made by management in Taylorism should in theory be similar to an impersonal rule-based system as in the case of algorithmic management because they should be guided by scientific analysis. However, in both cases the principles guiding the decisions (or algorithms) are set by higher management and are always political rather than technical. Finally, both systems can result in the minimisation of the degree of power and control that individual workers have over the production process.

However, this argument should not be taken too far. Some recent evidence suggests that algorithmic management systems in the context of digital labour platforms can be also associated to high levels of autonomy and low standardization from the perspective of workers, with control being operated at the end of the labour process rather than during it as would be typical in Tayloristic systems (Wood et al. 2019). This contrasting evidence points to the coexistence of rather different forms of algorithmic management in terms of control and standardization: some of these forms may be considered as enhanced (or digital) forms of Taylorism but some others clearly not.

Other precedents of algorithmic management, as defined in this paper, can be found in Information Technology (IT) firms, business process outsourcing (BPO) companies and call centres. Workers and firms in these contexts collaborate and coordinate work across different locations for a particular project through virtual platforms, and they use algorithms as a mode of organization (Aneesh, 2009). This was also referred to as 'algocratic' governance as the work was 'governed through the design of the work process . . . using software code to govern globally dispersed workers through data servers' (Aneesh, 2009: 347). As the governance mechanism was embedded in the global software platforms, it enabled the monitoring of work through the design of the work process itself (Aneesh, 2009). The organization of work within the business process outsourcing model was implemented through techno-bureaucratic control, wherein legal rules and supervision were used to control work processes (Taylor and Bain, 2005), supported by the penetration of Information and Communication Technology (ICT).

In general, the development and use of information management systems led many of the existing bureaucratic procedures, rules and routine tasks to be standardized and translated into software systems in several sectors. The use of such systems by large firms for managing their projects with their suppliers or subcontractors is another precedent of algorithmic management. These management systems (mentioned sometimes under the umbrella term of data-driven forms of management) establish common routines and systematic procedures for undertaking the tasks and solving problems across different sites and steps in the production process. At the same time these management systems allow for establishing work plans and patterns, monitoring, evaluating and delivering the products or services, and define procedures, resources, roles and responsibilities.

[5] In this sense, scientific management is more political than bureaucracy and more intrinsically linked to capitalism. However, even if bureaucracy is not ostensibly political, it has political implications, as bureaucracy is literally a power structure; and even if scientific management is ostensibly linked to capitalist power relations, it was widely (and successfully) implemented in Soviet Russia and other non-capitalist economic systems.

2.3 Where is algorithmic management being used?

In practical terms, algorithmic management is most widespread and developed in digital labour platforms. Outside digital labour platforms, in the regular[6] economy, the use of algorithmic management is less developed, although the Covid-19 pandemic has probably given it a significant push.

Digital labour platforms can in fact be understood as the embodiment of algorithmic management into a new type of economic organisation. Digital labour platforms are private companies that provide a digital platform where people that supply and demand some types of labour services can register. Then, the platform incorporates a series of algorithms for matching suppliers and consumers of those labour services, and for coordinating the provision of those labour services. Thus, going back to the classical distinction of the five key functions of management proposed by Fayol (2016, originally 1916), digital labour platforms incorporate algorithmic management for all those functions. The matching algorithms of digital labour platforms perform the staffing function; whereas the functions of commanding, coordinating and controlling (or direction, evaluation and discipline in the formulation by Edwards 1979) are performed by the algorithms for coordinating the provision of labour services. Even the critical function of planning is at least assisted by algorithms in digital labour platforms, although the key underlying business and strategic decisions remain under the control of the (human) managers of the actual companies behind digital labour platforms.

Digital labour platforms show that the degree of automation of the management of work can indeed become very high using algorithms, even if it can never be fully automated as discussed earlier (see box 1). But on the other hand, digital labour platforms also show that there can be a very wide variety of forms of algorithmic management, with very different implications for work organisation and workers well-being (Eurofound, 2019). The variety of algorithmic management forms can be as wide as that of human management practices. Some digital labour platforms incorporate very high and intrusive levels of (algorithmic) control for many aspects of the work process, including for instance the methods of work, the timing, the level of effort required. Yet, other digital labour platforms include only some limited and flexible forms of control, coming very close to the concept of management by objectives. However, it should be noted that even in the less intrusive digital labour platforms (typically those dealing with high qualified professional labour services), there are always some forms of algorithmic control of the work process, in addition to the algorithmic matching of suppliers and customers, because the DLPs business model is built upon those two principles (algorithmic matching and control).

The use of algorithmic management outside digital labour platforms, in regular economic organisations, exists but is comparatively marginal (Wood, 2021; Bernhardt, Kresge and Suleiman, 2021). In the regular economy, most of the management of labour is still carried out by humans rather than algorithms. In most cases, the labour process is not sufficiently digitised to allow significant degrees of algorithmic management. That said, there are some reasons for expecting the use of algorithmic management in regular organisations to grow in the near future.

The main reason to expect algorithmic management to grow in importance is the relentless and pervasive digitisation of all kinds of economic processes, including labour transactions that occur within and across economic organisations. As previously argued, the digitisation of a process is a precondition for the application of algorithms to the management of that process. Thus, the increasing digitisation of everything is a factor that would at least facilitate the increasing use of algorithms for the management of labour (and beyond labour). In fact, digitisation does not only facilitate, but also foster the growing use of algorithmic management. Without some degree of algorithmic control, it would simply be impossible to manage the enormous amount of information

[6] In this paper, the term 'regular' (applied to the economy or the labour market) is used in its sense of 'typical', 'standard', 'customary' and 'conventional', in opposition to the more recently emerged platform economy, jobs and work settings.

which is created by the digitisation of economic processes, and once digitisation has reached a certain level it will probably be economically advantageous to automate some management tasks for the coordination of labour input. And even if this algorithmic control does not explicitly or directly affect the management of labour input, it is likely to affect it indirectly. For instance, the collection of real-time and geolocated data about products and processes in a factory (the so-called Internet of Things systems) is generally managed by centralised data servers which implement automated (algorithmic) systems for processing that data and transforming it into useful intelligence. Even if that intelligence is not explicitly aimed at measuring the performance of workers, it will probably be very relevant in that respect and managers are likely to use it for that purpose.

This trend has been accelerated during the COVID crisis of 2020-2022. The urgent need to reduce face-to-face interaction forced companies around the world to shift to telework or remote work, which was, up to that point, only marginally used. In the worst periods of the pandemic, essentially anyone that could telework did so, and thus the effective rate of telework went from less than 5 per cent to between 20 and 30 per cent of overall employment (Sostero et al., 2020). And even in sectors that could not shift to telework or remote work (such as manufacturing), the need to minimise health risks often involved the introduction of new digital systems to control workers' proximity and interaction in the workplace. Although some of these changes might be reverted, many of them will remain in one way or another. Companies and workers have learnt that telework or remote work is both feasible and (at least to some extent) desirable, and thus are likely to use such a mode of work arrangement to a higher degree than before the pandemic. Additionally, some of the technology (devices and apps) introduced, skills acquired, and practices adopted are likely to remain. These changes could lead to a significant acceleration and deepening of the digitisation of economic and labour processes and are thus likely to facilitate a further expansion of algorithmic management in regular workplaces.

3 Algorithmic management on digital labour platforms

3.1 The centrality of data in digital platforms and algorithmic management

Data has become an increasingly valuable and strategic economic resource (Rani and Singh, 2019). The collection, processing and transfer of data related to work has become integral to the business model of digital platforms, and beyond platforms in regular workplaces. Platforms, which provide digital environments for all kinds of interactions,[7] have emerged as spaces where vast amounts of data can be collected from several sources (websites, internet-based devices such as mobile phones, and so on), as well as from users such as workers, clients and customers using trackers and other digital tools. This data can then be used for algorithmic management practices at a much larger and complex scale than ever before. The speed with which the data can be used for providing a range of services and products, as well as for training machine-learning algorithms and for automated decision-making can be the breaking point for the emergence of what some have called an "algorithmic panopticon" (Woodcock, 2020; Pasquinelli, 2015). For instance, on a taxi platform, 'datafication' (i.e. the pervasive translation of information into data) allows platforms to train algorithms, improve their functioning and exert control over the drivers. At the same time, platforms can utilize this data to develop other products, such as training autonomous vehicle systems (ILO, 2021).

Platforms often consider the data they collect to be their property, even though it is generated by users (workers, customers and clients) and some platforms explicitly mention it as an asset in their annual reports (Upwork, 2019). The accumulation of data among a few companies or digital plat-

[7] By the definition provided in section 2, digital platforms are broader than digital labour platforms, including multinational companies such as Alibaba, Alphabet (includes Google), Amazon, Apple, Meta (includes Facebook), Microsoft and Tencent, which provide cloud infrastructure and other services not necessarily linked to labour provisions.

forms can lead to a concentration of market power as these actors can leverage and monetize the data to create revenue (Sadowski, 2016) and become data monopolies ("data-opolies") (Stucke, 2018). For instance, when platforms such as Uber or Just Eat Takeaway acquire their competitors, data is one of the key assets they acquire as part of the transactions (ILO, 2021). Such concentration of data among few companies is not only concerning with regard to privacy, but also with regard to user rights as the data should be treated as a right of those who generate it and not as an asset owned by the company or platform that collects it (ILO, 2021; Rani and Singh, 2019; Arrieta-Ibarra et al., 2018). In most jurisdictions, except the European Union, workers do not have access to or control over their data, and they have very little information about their usage.

The availability of data on a massive and unprecedented scale, coupled with enhanced computing capacities and cloud infrastructure to store the data, has led to major breakthroughs in artificial intelligence technologies. The vast amount of data gathered plays an important role in algorithmic management practices pioneered on ride-hailing platforms (Lee et al., 2015). These platforms benefit from the invisible (and unpaid) "data work" performed by the drivers while transporting people, as data are constantly fed into the platform database for training algorithms (Chen and Qiu, 2019), while the driver is subjected to more control (Chen, 2018). The training of machine-learning algorithms can adopt patterns of humans performing similar tasks and to improve automated decision-making processes (ILO, 2021; Arrieta-Ibarra et al., 2018; Choudary, 2018). The privacy policy of some of the platforms such as Uber, Deliveroo, Upwork, Freelancer mentions the use of data for training machine learning algorithms and automated decision-making processes. For instance, Uber specifies that data is used for automated decision-making to enable dynamic pricing, to match drivers with passengers, and to deactivate users with low ratings. Similarly, online Freelancer and Upwork platforms specify that they use data for automated decision-making to match freelancers and clients, and to improve and train machine-learning algorithms.

The data collected allows platforms to develop an efficient matching system and gives them new forms of control over workers (Pichault and McKeown, 2019; Wood et al., 2019). The accumulated data and asymmetry of information on these platforms creates a power imbalance (Hanrahan et al., 2019) and gives platforms more power to exert management control (Rosenblat and Stark, 2016). This control is often exercised by the platforms through their design features and algorithms, programmed by humans (Rani and Furrer, 2021) to transform the data, from an input into a desired output (Gillespie, 2014: p. 167). The data are integral to algorithmic management practices in digital labour platforms and are used to shape the work processes and to structure the relationship with workers.

The data and the algorithms are used in digital labour platforms to perform the various functions of management mentioned in the previous section: planning and organising of work; commanding and coordinating, which entails allocation of work and direction of workers; and controlling, through monitoring and evaluation of workers, as well as by disciplining and rewarding workers (Wood, 2021; ILO, 2021; Kellogg et al., 2020; Moore and Joyce, 2020; Griesbach et al., 2019; Lee et al., 2015). The data along with the algorithms strengthens platforms' screening and monitoring powers, which can have significant implications for workers' access to work on platforms and their conditions of work. Since platforms are the environment where algorithmic management practices are most developed, the following sub-sections explore the use of data for the various functions of algorithmic management practices in selected digital labour platforms (online freelance, microtask, competitive programming; and location-based taxi and delivery) and outline the direct effects that these practices have on working conditions.

3.2 Algorithmic planning and strategy

Algorithmic planning and strategy are not widespread in all types of platforms as it continues to be largely performed by human managers, rather than being automated. It is nevertheless at least partly found in some of the ride-hailing or taxi and delivery platforms. In these platforms, the real-time data generated by drivers is a valuable competitive advantage for the platforms to specify

their pricing strategy. Based on the demand and supply during peak hours and traffic patterns recorded by real-time data, platforms, using their algorithms, can take immediate decisions for "surge pricing" (ILO, 2021; Duggan et al., 2020; Rosenblat and Stark, 2016). This pricing strategy is used by platforms to attract drivers to peak demand zones with the possibility to get a better fare while ensuring that the needs of the customers are met. To ensure that drivers are available in these zones, platforms send messages to them about peak zones and the ride fares. This allows platforms to steer drivers to areas or neighbourhoods where the supply is low (ILO, 2021; Rosenblat and Stark, 2016). Drivers often move to such areas either to make the additional income or due to the fear that non-accepting rides during peak demand might have future consequences for accessing work (ILO, 2021). However, this strategy can have an impact on workers earnings and welfare as depending upon the situation the ride fares can fluctuate and can be reduced to below the basic minimum to attract customers.

Similarly, to ensure continuous availability and supply of workers at all hours and especially during peak demand periods such as evenings or weekends, some delivery platforms like Deliveroo or PedidosYa plan worker schedules and slots in advance. Workers who have high ratings are then allowed to pre-book their schedules or preferred slots, giving them some flexibility in scheduling their working hours. The allotment of slots is algorithmically managed based on the worker ratings (ILO, 2021). However, the strategy to attract customers is similar to a traditional mechanism of providing discounts and premium memberships.

3.3 Algorithmic allocation of work and direction

There has been a paradigm shift in human resource practices on platforms with regard to allocating work and directing workers, as the data collected allows for automatic decision-making with little human intervention. However, the extent of automation differs across the different types of platforms.

The data compiled by taxi platforms allows them to match a customer who is looking for a car in a specific location with a driver in a few minutes. The algorithm to assign the task to the driver is based on the estimated time of arrival, driver's ratings and review by the customer, and the number of rides cancelled or accepted by the driver. The drivers often have 15 to 40 seconds to decide whether to accept or decline a ride based on limited information about the passenger's destination, making it difficult to judge if it would be profitable (ILO, 2021; Rosenblat and Stark, 2016). The allocation of tasks on delivery platforms is also automated and their work schedules and destination are shaped by their ratings, the number of hours worked, and orders accepted during specific days and time slots (ILO, 2021). There is very little transparency in the algorithmic matching process on ride-hailing and delivery platforms as to why a particular driver or delivery worker is allocated or chosen for the ride or order, when there are multiple drivers or delivery workers in a particular location. The algorithm allows the platforms to exert considerable control over drivers and delivery workers regarding who gets a particular ride (short or long one) or order and to which neighbourhood. The data tracked on platforms enables them to define and instruct the optimal routes that workers should take to provide the service within a short time taking into consideration the traffic situation based on the GPS (ILO, 2021).

On most microtask platforms, tasks are automatically made available to the eligible workers using the algorithm, based on their ratings and other parameters such as age, gender, or the country where they are based. Workers can perform these tasks on a first-come, first-serve basis. Yet, the design features of the platform can have an impact on workers access to work, as the platforms or their clients can decide whether a particular task is performed by a global pool of labour or by specific populations based on certain characteristics, which restricts workers from certain countries from accessing work (ILO, 2021; Rani and Furrer, 2021). Workers are often directed to perform tasks as per the instructions provided by the clients and platforms often allow clients to determine the time limit (minutes or seconds) for completing a specific task, and if the worker is unable to

complete the task within the allotted time, they can lose their task as well as the payment (Rani and Furrer, 2021).

The extent of automation regarding the allocation of tasks or projects to workers varies across freelance platforms. Some platforms such as Freelancer and PeoplePerHour exclusively use algorithmic processes to match workers and clients based on certain targeted indicators. Other platforms such as Toptal and Upwork use semi-automated processes wherein the top three to five workers are initially short-listed using algorithms. A specialist (human manager) from the platform is then assigned to the client to support with the final process of identifying the appropriate worker for the specific task or project. The targeted indicators that the algorithms use to match workers with clients vary across different platforms, which makes data portability across platforms difficult (ILO, 2021). The algorithms on some of the freelance platforms such as Upwork or PeoplePerHour are also designed in such a way that they account for paid subscriptions or membership plans, or paid services, or paid 'connects' and 'proposal credits' to bid for projects. As a result, workers who have subscriptions, or membership plans or are subscribed to paid services have higher chances of getting projects and tasks.

While this process shifts the costs of intermediation transactions to workers, it can also lead to *de facto* discrimination as workers who do not have the financial capacity to make such investments, will not be able to participate on such platforms. Empirical evidence on both microtask and freelance platforms shows that workers especially from developing countries report being paid less for the task because of their place of residence and not getting access to well-paid tasks, which are often restricted to workers from advanced economies (ILO, 2021; Galperin and Greppi, 2017; Beerepoot and Lambregts, 2015). Although platforms enable workers to 'self-schedule' their work plans and determine how many hours they wish to work, their freedom, flexibility and autonomy is restrained by the contractual agreement they have with their clients, as they are directed to install tools, deliver work and be available at a specified time. For instance, for fixed-price jobs on Upwork and Freelancer, the projects are organized by milestones, and workers are directed to record their work activity and update their status report on a regular basis for each milestone.

On competitive programming platforms, all the coders, developers or data scientists who are registered are invited for competitions and challenges related to innovations and creative software solutions. However, there are also competitions which are either private or by invite only, where algorithms may be used to limit the participation depending upon the needs of the clients. For instance, some challenges and competitions are open to all developers, coders and programmers on Topcoder, while in other challenges, managers depending on the needs of the client may use the automated scoring system to invite only the highly rated or ranked programmers from the community to participate. This strategy is adopted to ensure quality submissions and to minimize the costs of evaluation (Lakhani, Garvin and Lonstein, 2012). The programmers are directed to submit the challenges within the specified time limit set by the clients as per the codes of conduct, which is often specific to the platform (ILO, 2021).

3.4 Algorithmic control and monitoring of workers

Digital labour platforms facilitate the continuous control and monitoring of workers (Duggan et al., 2020, Pesole, 2021), and some of these monitoring processes are automated. The monitoring process of freelance platforms is through the provision of various tools for clients, which allows them to communicate with workers, manage, and monitor the work progress continuously. Workers are often required to install software and hardware requirements and these are laid down in the terms of service agreements of the platforms. For instance, Upwork provides their workers on an hourly contract with a "work diary", which when enabled by the worker records the number of hours worked, number of keystrokes made and takes random screenshots (six times an hour) while they work on a project. The clients are given access to this information, and they can track the working hours and monitor the activity and progress of the worker in real-time. The ILO survey of workers on freelance platforms shows that more than 40 per cent of the workers reported regularly being

tracked for working hours, submitting screenshots of their work and being available at a specified time (ILO, 2021). The degree of monitoring using digital tools and the control that the platforms exercise over the workers often resembles a subordinate employment relationship (Rogers, 2018), and not as "self-employed" or "independent contractors" as they are typically classified.

The monitoring and control mechanism on microtask platforms is done using algorithms that decides whether the work is performed according to the task specifications. Some platforms also allow clients to check how much attention a worker is paying to a task by adding test questions. If a worker gives too many incorrect responses, he/she loses access to that task and forgoes payment for it, and it has an impact on his/her ratings (Rani and Furrer, 2021).

Competitive programming platforms monitor participants during challenges and competition to ensure that there is no cheating, or ideas are not being shared during competition, or unauthorized codes are not being utilised. Most of these platforms provide software tools and clear codes of conduct to participants to ensure that highest standards are maintained. For instance, Kaggle monitors its compliance account, which is a formal channel for reporting cheaters, and in case of violation of the rule's individuals can be removed from the competition or their accounts can be banned.[8]

Navigation technologies such as GPS on taxi and delivery platforms continuously monitor and track worker behaviour by gathering data on driving speed, brakes and acceleration and the precise location of the worker (ILO, 2021; De Stefano, 2019; Choudary, 2018). They also allow platforms to monitor the time taken to complete the order or ride. The data tracked in real time allows platforms such as Uber to determine if any driver is behaving erratically or irresponsibly, and they can algorithmically recommend a driver to go home or rest (Scheiber, 2017; Rosenblat and Stark, 2016). This form of monitoring and surveillance affects workers livelihoods and welfare. It often also leads to workers self-disciplining and policing their behaviour to ensure that they have good ratings from custormers and continuous access to work, which was reported by taxi drivers in the ILO survey. The movements of delivery workers are closely monitored by the platforms and are also tracked by clients in real time. This increases the pressure on workers to reach their destinations faster, as even a slight delay can have an impact on their future orders as well as their ratings (ILO, 2021).

3.5 More on control: Algorithmic evaluation and rating of workers

The evaluation of performance using algorithms is yet another way of redefining work relationships and replacing human supervision (ILO, 2021). Ratings is an important mechanism through which workers performance is evaluated and control can be exercised. It includes several metrics or indicators and differs across platforms, even within the same sector such as taxi or freelance. There is little transparency about how the rating is determined and the relative weight of the different indicators used in the algorithms to evaluate workers performance. This makes the portability of ratings across platforms difficult and gives platforms exclusive control over their workers as they are locked-in. The high costs in terms of time and financial resources required to build their profile and ratings on the platforms also dissuade workers from working on multiple platforms. This is especially so on freelance and microtask platforms, as workers have to build up their reputations in each platform from scratch (ILO, 2021). Ratings often determine the nature and amount of work that workers can access or is assigned to them. In most types of digital labour platforms, any delay or non-completion of work impacts ratings negatively.

Workers on taxi platforms are evaluated based on their ratings and reviews given by customers, which is an important performance metric, in addition to their cancellation rates. As mentioned earlier, on ride-hailing platforms drivers are monitored using navigation technologies which also track drivers' engagement and behaviour with the customers. These measures are also used as indicators

[8] See for more details: https://www.kaggle.com/docs/competitions

in their rating and can ultimately determine the drivers' access to rides. As a result, workers self-discipline and are often obliged to be friendly, polite, cheerful, disciplined, have a good appearance and provide good customer service to ensure good rating (Rani, Gobel and Dhir, 2022a). The algorithmic management practices for evaluation are also intertwined with the flexibility and autonomy that workers experience on such platforms. As the ratings are dependent on the number of rides that are accepted or cancelled, workers often do not enjoy the flexibility or autonomy to cancel a ride as it has consequences for them. About 40 per cent of the taxi drivers in the ILO survey reported that their ratings were lowered because they had cancelled rides (Rani, Gobel and Dhir, 2022a).

On delivery platforms, workers are evaluated based on whether they participate during peak periods, number of deliveries and the speed at which they deliver, apart from their cancellation rate. These indicators play a critical role in workers receiving good feedback from customers and business partners (restaurants, grocery shops, etc.), which influences their ratings. However, not having the ability to cancel the orders can at times lead to long working hours and on average workers reported working 59 hours per week in some of the developing countries (ILO, 2021). The long working hours and the pressure to drive quickly can have severe implications for worker's occupational health and safety, especially when many of them do not have access to social protection. About 45 per cent of the delivery workers in the ILO survey reported being stressed by their work and working conditions (ILO, 2021).

The evaluative role of management on microtask platforms is often automated through a predefined coding system (algorithm), which evaluates the task once it is completed by the worker. The automated system accepts or rejects the tasks based on predefined criteria. For instance, on CrowdFlower each individual task is assigned to multiple workers; then, a quorum system compares and evaluates which responses are correct. Payment is made to the worker only if the task is accepted by the algorithm. While there is some possibility of communication between the worker and the client on platforms such as Amazon Mechanical Turk (AMT) and Prolific, there is no such a communication on others such as Clickworker, CrowdFlower and Microworkers (Berg et al., 2018). Workers are often frustrated as they do not have feedback from the clients for the rejection of the task, and they are unable to improve their performance or correct their mistakes. The rejection of work impacts their ratings and reputation negatively (ILO, 2021; Berg et al., 2018).

Client reviews and feedback are quite decisive for workers ratings on freelance platforms. These play a critical role in accessing work and to establish long-term relationships with clients and build trust (Huws et al., 2018; Gandini, Pais and Beraldo, 2016). Feedback from the clients is very important on these platforms as not getting feedback implies that the worker has not completed the job, which will automatically impact the success rate as well as the overall ratings. While top-rated workers can dispute and contest their ratings, most workers cannot and there is a lot of pressure on them to get the client reviews. Similarly, on some platforms, rules can be flouted, wherein the top-rated workers are allowed to remove or hide a certain number of low ratings from their profile, as was reported by workers in the ILO survey (ILO, 2021). Given the prevalence of such practices, the usefulness of such a rating system can be questioned as it can be manipulated to serve the purpose of the platform rather than assessing the quality of work of workers (Rani, Dhir and Gobel, 2022b).

The evaluation process on competitive programming platforms is done automatically based on certain pre-defined parameters, as well as by managers (human) or a network of evaluators from its community. For instance, Topcoder can recommend its clients workers from the Topcoder community to assist with the project as co-pilot, who then evaluate the worker submissions to find the best solution to the problem (Boudreau et al., 2015). Similarly, on HackerEarth when challenges cannot be automatically evaluated, the platform is assisted by individuals from the community who are willing to play the role of evaluators (Srinivasan et al., 2017). In addition to automating, platforms also externalise a significant share of their evaluation process to their crowd or community. The workers on these platforms are ranked based on an Elo rating system, which calculates a worker's expected rank in a contest based on the performance of other participants in the competition, along with a number of other factors (ILO, 2021).

3.6 Algorithmic disciplining and rewarding of workers

To ensure that workers are compliant with the rules and cooperative with the clients and customers, platforms continuously try to discipline workers using two main mechanisms. First, platforms use incentives and rewards to discipline workers. Second, disciplining is often also achieved through punishing when workers digress from performing the task by restricting access to work or deactivating them temporarily or permanently. In addition, as observed earlier, workers are often aware of intense competition due to oversupply of workers irrespective of the type of platform, which automatically also leads to self-disciplining to ensure continuous access to work.

Taxi platforms incentivise drivers through bonuses to retain them, which are also used as a mechanism for discipline. The strategy differs across countries depending on local demand, cultural context and competitors. For instance, Uber offers such bonuses for completing a certain number of rides, or for working during specific times (peak demand) or working during asocial hours. These bonuses are not offered to all taxi drivers but only to those who have high ratings: about three quarters of the taxi drivers reported being offered bonuses in the ILO survey (ILO, 2021). The bonuses help platforms to discipline workers while at the same time ensuring a steady supply of drivers during the nights and weekends. Workers are attracted to such bonuses as they can earn additional income and this often leads to long working hours (ILO, 2021; Verma et al., 2020; Chen, 2018; Rosenblat and Stark 2016). However, workers also reported being frustrated that after a certain period of time it becomes challenging for them to reach the targets and earn the bonuses despite working long hours. This is because the algorithms are set in a way that they often would not assign them enough rides when they were close to reaching their target, which was reported by 43 per cent of the taxi drivers in the ILO survey (ILO, 2021), as also observed in other studies (Rosenblat and Stark, 2016).

Disciplining workers through deactivating their accounts temporarily or permanently is quite popular across all platforms. Deactivation is often triggered by low ratings, bad reviews, and complaints from customers. A sizable proportion of taxi drivers in the ILO survey reported such incidents. On microtask platforms, workers who are underperforming or have ratings below a certain threshold are deactivated from the platform automatically without any human involvement. For instance, on AMT, workers who have their ratings below a particular threshold (95 per cent) might not receive tasks and their account is subsequently deactivated without any notice (Rani and Furrer, 2021). As the entire process is automated, workers are often unable to find out why their work was rejected, or their account deactivated, or why they received a low rating. Algorithmic rating carries a lot of weight on freelance platforms, and low ratings can restrict access to work opportunities (ILO, 2021; Wood et al., 2019).

In summary, by presenting recent evidence and examples from the algorithmic management of work in digital labour platforms, this section has shown that the introduction of algorithms to perform the different functions of management implies a fundamental departure from traditional human management practices. While not all the functions of management can be automated in all types of platforms, new forms of control, monitoring and disciplining of workers are clearly emerging on digital labour platforms.

4 Algorithmic management in regular workplaces

4.1 The expansion and adaptation of algorithmic management in regular workplaces

Being intrinsic in their functioning, algorithmic management has developed most in digital labour platforms. Due to the increasing digitisation of processes in regular organisations, however, it is progressively documented also in other work settings (Clarke, 2021; Wood, 2021; Bernhardt, Kresge and Suleiman, 2021; Kellogg et al., 2020). The use of algorithmic management in digital labour platforms can be used as a model for understanding its nature and implications in more general

terms, extending to broader contexts. However, in regular workplaces, algorithmic management might differ, to some extent, from what has been observed in digital labour platforms, due to the interaction of algorithmic management practices with pre-existing organisational structures and features.

As mentioned earlier algorithmic management has emerged within long and broad trends of transformation and (re-)organisation of economic activity, with some forms of data-driven management decisions being already in place in regular firms. A wide range of digital technologies introduced since the 1980s have allowed for collecting data about the work process, which was then reported to and analysed by management to take business decisions (Zuboff, 1988, 1985). Some specific applications of ICT (i.e. software) to coordinate work have also been mentioned in previous sections, for instance in the context of IT and call centres (Aneesh, 2009). These possibilities have expanded the scope and extent of management practices using digital technologies, and regular workplaces are adopting specific algorithmic management practices typical of digital labour platforms. For example, ratings that quantify client's satisfaction, are becoming a significant managerial tool also in regular service industries beyond digital labour platforms (Wu et al., 2019).

Although they are less pervasive and less developed, we can find examples of algorithmic management practices in regular workplaces. It is widely documented such as in logistics, including transportation, storage and delivery services, with modalities very similar to those found in ride hailing and delivery platforms as described in Section 3 (Dzeiza, 2020; Delfanti, 2019). Depending on sectoral characteristics, the implementation of algorithmic management is developing at different paces across the economy (Mateescu and Nguyen, 2019). It is also progressing in the retail, and food and accommodation sector, from hotels to food chains, including the algorithmic allocation of work shifts to coordinate and command, and rating systems for algorithmic monitoring and evaluation to control workers (Bernhardt, Kresge and Suleiman, 2021; Mateescu and Nguyen, 2019). Similar practices are found in other service industries, such as banks, consultancies, call centres, journalism, as well as in manufacturing (Wood, 2021). Digital technologies are being introduced also in public services such as healthcare (Clarke, 2021; Ito-Masui et al., 2021) and police (Wood, 2021), for example through wearables that can continuously monitor workers, their interactions and movements to provide data for management decisions. Across all sectors, companies as well as public organisations are introducing AI-based recruitment practices to screen prospective employees and manage recruitment processes (Köchling and Wehner, 2020; Yarger et al., 2020). The rapid pace of introduction of digital technologies enabling algorithmic management suggests that in the long run no sector will remain unaffected by algorithmic operations (Adams-Prassl, 2019).

In regular workplaces, however, algorithms remain less frequently used for work management purposes, or at least they are not systematically adopted. Moreover, the survey of literature reveals that in most cases even when applied to a particular work context, these algorithms tend to assist rather than automate human decision making (Wood 2021). After all, digital labour platforms have been built on algorithmic management practices since their inception, and that might be why algorithmic management is most advanced and "pure" in this context. In regular workplaces, instead, algorithmic management practices have to be implemented over pre-existing structures and processes of work organisation (Jarrahi et al., 2021; Orlikowski, 2007), which can make algorithmic management less easy to identify, at least at a first glimpse.

Nonetheless, despite the specificities that algorithmic management might present in these settings, according to the definition and conceptualisation presented in earlier sections, three elements remain essential to identify algorithmic management beyond digital labour platforms. These elements allow identifying algorithmic management in different contexts regardless of the level of development and automation that it implies. Such elements are: the data about the workers and/or the work process to feed the algorithms, the processing and elaboration of such data through the algorithms, and the coordination and control exerted on workers through the management decisions made or supported thanks to the previous two elements (Adams-Prassl, 2019).

Through these three elements, interacting with and adapting to pre-existing forms of work organisation and other organisational features, algorithmic management practices introduce changes in regular work settings that are potentially disruptive. Algorithmic management changes work organisation within and beyond the organisation (in fact blurring this boundary, as discussed later in the section). As a consequence, it is likely to impact several aspects of job quality. These changes are summarised in Figure 2 and discussed in detail in the sub-sections.

Figure 2: Algorithmic management and its implications in regular work settings

Source: Authors' compilation.

4.2 Changes on work organization

Allowing the execution of management functions through an unprecedented amount of data and processing power, algorithmic management can introduce changes in work organisation through three main channels. First, it can centralise knowledge and control, thus shifting the power balance within the organisation (Mateescu and Nguyen 2019; Delfanti 2019). Second, it can redefine tasks and roles, possibly making some profiles redundant and downgrading others (Delfanti, 2019; Lee et al., 2015). And finally, it can blur the boundaries of the organisation (Adams-Prassl 2019).

4.2.1 Centralisation of knowledge and control

Monitoring and surveillance can reach the most pervasive forms when it involves individual workers, is performed in real-time, communicates results publicly and entails both assignment and tracking of tasks (Grant and Higgins, 1989 in Ball, 2021: 61). Although these characteristics of monitoring and surveillance could be found in workplaces even before the introduction of algorithmic management, these technologies are becoming easier to implement with digital tools and can be deployed to introduce algorithmic management in regular work settings (Edwards et al., 2018 in Moore, 2020).

Thanks to these technologies, data are collected on a wider range of aspects than before, with higher granularity and more subtle methods. Digital technologies do not limit monitoring to performance, but can also extend to behaviours and personal characteristics, often entangled together by the "function creep", namely the use of information for other purposes than the specified original ones (Ball, 2010: 90). The scope of monitoring and surveillance does not limit to check that tasks are performed as desired (i.e. to ensure enforcement of instructions and/or compliance to the employment contract), but it can include data collection (and following elaboration) to optimise the process (i.e. to improve overall efficiency and productivity, including moving to lean production and ultimately also reduce labour costs) (Moore and Robinson 2016).

Data and algorithms in the workplace, therefore, can result in what has been called the "quantified self at work" (Moore and Robinson 2016: 2): an attempt to fully quantify workers' experience in the process of goods production or service delivery. Although the full quantification of every aspect of

work is far from possible (Mateescu and Nguyen, 2019), the quantified self at work is conceived as 'objective truth' about what happens in production or service delivery, disqualifying every aspect of the process that is not quantifiable and thus cannot be controlled centrally. This data and its elaboration can normally be accessed and processed almost exclusively by the management of the organisation, which leads to a centralisation of (codifiable) knowledge that flows from workers towards the management of the organisation.

Centralised knowledge translates into a centralisation of control over the work process (and the production in general terms) (Braverman, 1974). In a process that Delfanti (2019) calls "machinic dispossession", pervasive monitoring and surveillance in algorithmic management leads to information asymmetries where knowledge, and thus control, over production is concentrated at the management level. Management acquires exclusivity on such knowledge, about the tasks to perform, how to perform them, how to improve such performance, especially when there is little transparency about the data and the algorithms used.

As algorithmic management centralises knowledge and control, the information asymmetries between management and workers can create power imbalances similar to those mentioned already in the context of digital labour platforms, which tend to deepen as transparency around algorithms and data is denied or limited. The management (and the associated algorithmic systems) not only centralises the knowledge and plans for production, but can directly assign and control what workers have to do in a real-time basis. Similarly, management can assess performance based on real-time data and complex algorithmic processing, while workers may be unaware of these criteria, the results and the implications of these evaluations (Delfanti, 2019). This is how algorithmic management can lead to a shift in the power balances between workers and management within an organisation (Jarrahi et al., 2021), with potential detrimental effects, ultimately, also in terms for industrial relations and bargaining.

4.2.2 Redefinition of tasks and roles

By centralising control and implementing management functions in a (semi) automatic manner, algorithmic management affects tasks and roles within the organisations where it is adopted. The centralisation of knowledge and control that characterises algorithmic management fosters the standardisation of processes, which is in turn accompanied by a routinisation of jobs and tasks across several occupational levels. In particular, algorithms that assist or implement management functions potentially have two main implications in terms of organisational tasks and roles: the shrinking of middle management and the *atomisation of work* across occupations.

Algorithmic management relies on the possibility to determine and communicate precisely and automatically what tasks to perform and how, as well as to assess levels of performance. To do this, the processes, each of their steps and their outcomes, need to be predictable. Predictability is achieved through standardisation, namely the adoption of explicit, codified and shared set of rules for actions to perform (in a process, in a job, in a task, etc.), which are decided by a restricted group within an organisation (Brunsson et al., 2012).

Standardisation is a fundamental step in the separation between conception and execution of work (Braverman, 1974; Burawoy, 1985), which can expand with algorithmic management. In effect, the standardisation of work processes predates algorithmic management as defined in this paper. It was pivotal in Taylorism and in systems such as Just-in-Time production or lean manufacturing, and it was fundamental for the automation waves of the previous century. However, it is mentioned more and more often in association with algorithmic management in digital labour platforms and beyond (e.g. Wood, 2021; Altenried, 2020, 2019; Delfanti, 2019; Lee et la., 2015). Algorithmic management is associated with a tendency to standardise jobs and tasks *ex-ante*, because standardised work and processes allow for the codification and control of all sorts of information about goods production or service delivery. Once processes and tasks are standardised, related information can be easily (digitally) encoded and used by algorithms to manage work as discussed earlier.

While standardisation is a typical mechanism of control in bureaucracy, however, in algorithmic management it can be implemented in an impersonal way by the algorithms themselves (which are essentially rules codified into automatic systems of digital control), rather than by a delegated human hierarchy as in traditional bureaucracy (Lee et al., 2015). Standardisation and automated decision-making by algorithms would tend to collapse work hierarchies, shrinking in particular middle- and low-level management positions. First, low- and middle-level management could be reduced because those in these roles can be (at least in theory) replaced by algorithms in their functions to facilitate the day-to-day implementation of work, the supervision of workers and the communication to and from top management. The extent to which low- and middle-level managers are redundant, however, depends on the actual degree of automation in decision-making that algorithmic management reaches (or is allowed to reach). It seems also plausible that rather than seeing their roles entirely replaced by algorithms, low- and middle-level management positions are transformed by the introduction of algorithmic management systems, becoming complementary to them. For instance, low- and middle-level management can intervene when the algorithms fail, or can fine-tune the parameters of the algorithms to each particular work situation, or can provide the flexibility that algorithms do not have in unforeseen situations.

Another possible impact of algorithmic management in this respect concerns occupations and occupational structures more broadly. As shown by digital labour platforms, algorithmic management can be used to efficiently coordinate very complex work processes involving a myriad of small labour inputs (e.g. crowdsourcing). Also in regular workplaces, this can facilitate a more detailed division of labour into smaller tasks to be performed by workers under the supervision of algorithms. Once each single task can be directed and controlled independently thanks to the capacity of algorithms to coordinate complex and numerous processes simultaneously, it does not seem so necessary to bundle those tasks together in predefined positions or jobs within the firm´s organisational structure. This can contribute to flattened organisational structures, but also to the *atomisation of work* (Olsen and Carmel, 2013; for examples in digital labour platforms see ILO, 2021; Urzí-Brancati et al., 2020; Pesole et al., 2018). This atomisation of work is also very much linked to the blurring of organisational boundaries discussed below.

4.2.3 Blurring of organisational boundaries

Employment contracts are used by organisations as mechanisms of control, to internalise the provision of some labour services that cannot be contracted in markets because the transaction costs would be too high (Casson, 1994; Coase, 1937). Control exertion, however, can be pursued differently with algorithmic management (Adams-Prassl, 2019). Algorithmic management can shift vertical relations (typical of the firm) to horizontal ones (typical of market transactions) and opens up possibilities for assigning and monitoring tasks beyond the boundaries of the organisation, and for managing work relations beyond internal hierarchies.

Centralised algorithmic control, in fact, lowers the transaction costs of externalising tasks, jobs, projects, etc., because it facilitates control over them, even when external (Adams-Prassl 2019). Moreover, standardisation in itself, which as discussed earlier is both required and facilitated by algorithmic management, can be viewed as a way to provide guidelines and control (i.e. standards) outside formal organizations and hence can be perceived as a governance mechanism that overcomes formal organisational boundaries (Brunsson et al., 2012). Extending control beyond the organisational boundaries, algorithmic management tends to blur such boundaries, raising issues of accountability and possibly driving new models of business and value chains. Blurred organisational boundaries means that work organisation tends to rely more often than before on external (market) relationships.

With algorithmic management, work can be organised more easily through subcontracting and outsourcing to other firms or to independent workers (Adams-Prassl, 2019; Delfanti, 2019, Moore and Robinson, 2016), or to crowdsource through digital labour platforms (ILO, 2021; Rani and Furrer, 2021; Cedefop, 2020). This way of organising work transcends employment relations internal to the organisation and entails an on-demand approach to work provided externally. The on-demand ap-

proach is facilitated by the standardisation and atomisation of work mentioned above. It also relies, however, on highly flexible planning and even scheduling which is made possible by fast and continuous collection and elaboration of data regarding the demand for goods or services (e.g. customer flows, demand-peaks in production), enabled by algorithmic management. Ultimately, this may decrease the need for a large permanent workforce internal to the organisation.

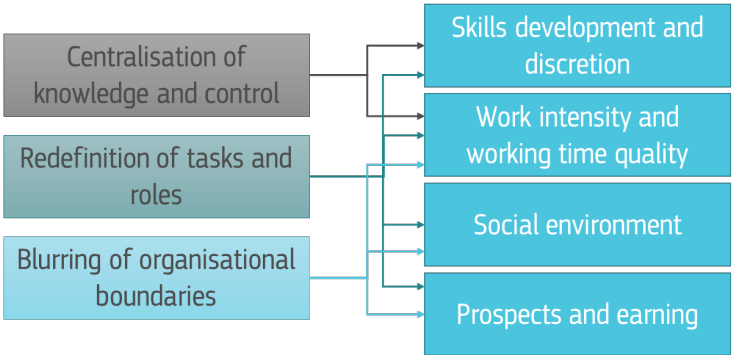
Another mechanism that blurs the boundaries of the organisation in coordinating work is the externalisation of workers' evaluation, as described for digital labour platforms in section 3. In regular workplaces that adopt algorithmic management, evaluation can be externalised by asking customers and clients to give feedback or ratings to the workers. These feedbacks and ratings are then used to make management decisions, while keeping the costs for monitoring and surveillance low. However, this system generates ambiguity on the evaluation criteria, limits workers' right to redress and shifts firm's social responsibility and (time) costs for evaluation to customers or clients (Adams-Prassls, 2019). Often, the externalisation of workers' evaluation is developed in the framework of quality assurance mechanisms, for example to monitor the quality of services provided to patients, users, clients or customers. However, it can result in 'refractive surveillance' through which, while monitoring general business aspects, the management acquires data that can be used to evaluate workers (Levy and Barocas, 2018). These mechanisms may concern especially social services (e.g. healthcare), but are more and more developed also for the provisions of food and accommodation services, or consultancy services. While typical of platforms, practices for external evaluation of workers are already found in the hospitality industry or for frontline workers in the food industry, such as waiters (Mateescu and Nguyen, 2019; Orlikowski and Scott, 2014).

4.3 Effects on job quality

The changes that algorithmic management introduces in work organisation may have detrimental effects on several aspects of job quality. Some of these effects have already been documented in the context of digital labour platforms, where, as said, algorithmic management is intrinsic and most developed. Section 3 has identified and discussed the impacts of algorithmic management practices on the working conditions and well-being of platform workers based on a large body of literature (also mentioned by other studies such as European Commission, 2020; Eurofound, 2018b, 2017, 2015; EU-OSHA, 2015, 2021). Among the most discussed impacts of algorithmic management on platform workers' job quality we can mention the following: job and income insecurity, due to unpredictability of work demands; difficulty to exert autonomous decisions in task performance to comply with the given instructions; accidents and mental distress at work; high work intensity to meet requirements or make a living working on platforms; and difficulties for work-life balance reconciliation because of unpredictable scheduling and prolonged online availability to get assigned tasks.

The experience and evidence in the context of digital labour platforms can provide a good starting point to map the possible job quality implications of algorithmic management in regular workplaces. However, the different context can lead algorithmic management in regular jobs and organisations to stress on some job quality issues more than others. This could result in differences in the overall job quality outcomes between workers in regular workplaces and those in digital labour platforms, despite both being subject to algorithmic management. The possible effects on several dimensions of job quality in regular workplaces also have to be discussed in relation to changes in work organisation, as summarised in Figure 3. These possible effects are briefly discussed below, bearing in mind that there might be nuances related to the organisation work setting and the jobs characteristics. This is indeed the area where empirical research can particularly advance, to help establish how algorithmic management affects working conditions and well-being beyond platform work, considering the specificity of regular workplaces and jobs.

Figure 3: Links between changes in work organisation and job quality dimensions



Source: Authors' compilation

4.3.1 Skills and discretion

The centralisation of control and the separation between conception and execution of work can translate, in principle, into a loss of autonomy for workers. As documented by the literature on the logistics sector (Wood, 2021; Dzeiza, 2020; Delfanti, 2019), workers often have to strictly follow algorithmic instructions in their job. Often workers have little possibility to override or even discuss these instructions with supervisors, because the data and the algorithms have already defined these instructions in the (supposed) optimal way. Pervasive monitoring and surveillance in the workplace can prevent workers from diverting from these instructions by making autonomous decisions, to avoid incurring in punishing measures (e.g. dismissal) or to try to achieve bonuses or rewards (Todolí-Signes, 2021).

Loss of autonomy is a job quality issue *per se* because it limits individual discretion and can lead to alienation and detachment from one's job (also linked to the detriment of the social environment, discussed below). Ultimately, it can decrease job satisfaction and contribute to emotional exhaustion. In addition, a prolonged loss of autonomy, due to the continuous repetition of discrete tasks under strict instructions, can prevent workers to use, practice and develop competences and knowledge in their job, which leads to the de-skilling of the workforce (Braverman, 1974).

The introduction of several technologies enabling algorithmic management is associated with an increased demand for skills (and possibly related training) to operate and interact with these technologies (Eurofound, 2021, 2020). However, a process of de-skilling may be fostered also by the standardisation and atomisation of work previously discussed. Both these processes can lead to a demand (from the organisation) and a need (of the worker) for skills that are very specific to discrete, short and very specific tasks to perform on an on-demand basis in a pre-defined (i.e. standardised) way, while diminishing and devaluing overarching competences and knowledge for the job.

In digital labour platforms, this lack of autonomy has been documented often in association with 'workaround' strategies that workers put in place to exert some discretion over the performance of the tasks assigned and circumvent, to some extent, algorithmic instructions (Kellogg et al. 2020; Lee et al., 2015). In regular workplaces (e.g. the typical office or factory work), however, workers might lack the remoteness (e.g. in terms of workplace) and the flexibility (e.g. in terms of working time) that are needed to arrange these workarounds without incurring in disfavouring disciplining measures. This, in comparison to what happens in platform work contexts, might worsen the effects of centralised control and redefined tasks on skills development and discretion in regular workplaces and ultimately on overall workers' well-being in this context.

4.3.2 Work intensity and working time quality

Centralised algorithmic control may also lead to work intensification and to worsened working time quality. The workload increases when the number of tasks to undertake increases and/or the time to complete these tasks decreases. Both these aspects are defined to meet the target set centrally

by the algorithms, rather than considering workers' situations or views. It follows that the workers have to adapt their pace of work to comply with what is requested, being subject to time pressure and consequent stress (Todolí-Signes, 2021). There is also empirical evidence of the association between the adoption of technology enabling algorithmic management and the dictation of the pace of work by machines or computers in regular workplaces (Eurofound, 2020).

Work intensification can also result from the redefinition of tasks and roles that algorithmic management operates in the organisations where it is introduced. For example, certain categories of workers (e.g. middle management or supervisors), whose role is transformed requiring to interact more often than before with algorithmic management technologies, may be pushed to increase the pace of work to align to the speed of algorithmic elaborations or decisions to implement. In addition, some workers may be required to perform additional tasks to interact with the algorithmic management systems and related enabling technologies, on top of their ordinary job tasks. Barrett et al. (2012) provide an example of work intensification in the context of a hospital pharmacy, wherein work intensification resulted both from the redefinition of workers' tasks and roles, and from the dictation of the exact time and the pace to perform job tasks.

In addition, the on-demand approach and the atomisation of work typical of blurred organisational boundaries tends to make work more precarious and unpredictable. On the one hand, when workers are contracted from time to time or in any case through precarious contracts, they might be pushed to work at a faster pace to ensure contract renewals, especially when these renewals are subject to algorithmic-driven decisions, rather than on evaluation by a human manager. They might also be pushed to perform the tasks more quickly or simultaneously to ensure an adequate level of income to make a living (also linked to the detriment of earnings discussed below). On the other hand, the demand for workers externally contracted might be driven by algorithmic decisions regarding the peak in demand for goods or services, based on several parameters that are not completely intelligible to workers themselves and can change frequently (e.g. weather, consumer patterns, etc.). In sectors such as healthcare, food and accommodation and retailing this might lead to unpredictability in the work schedules and might lead to unsocial working hours. While the worsening of working time quality may affect all workers, it might be more serious for those contracted externally as they are more subject to on-demand calls from the organisations. Wood (2021) discusses recent studies on the unpredictability of work schedules in logistics and food and accommodation services, where the scheduling or assignment of work shifts is also driven, from one day to another, by indicators on the worker's performance (see also Gent, 2018; Orlikowski and Scott, 2014).

These negative effects have been largely documented in digital labour platforms, but again, the lack of remoteness and of flexibility that characterise regular work settings could make the consequences of these effects worse in these contexts. In addition, for workers in regular jobs, work intensification might translate into longer working hours, increasing last-minute requests to work and necessity to be continuously connected to work communication. This can erode the pre-existing division between work and private life, between work and private space, possibly leading to increasing work-life conflicts.

4.3.3 Social environment

The changes in the work organisation produced by algorithmic management can have several implications for the social environment in regular jobs and organisations.

First, a redefinition of tasks and roles, associated to the atomisation of work and the limitation of low- and middle-level management functions, may reduce human interaction both with peers and with supervisors. Some workers may have to perform their tasks in isolation, especially when they are contracted externally, because their tasks are centrally and impersonally controlled by algorithms (Delfanti, 2019). Where middle management or supervisors are divested from their intermediating role in managing work, or when workers are contracted externally from the company, the workers do not have the possibility to exchange views and perceive empathy on their jobs (Todolí-Signes, 2021). This would imply a significant loss for the social environment because the role of human intermediation is found to be pivotal for a good social environment, for workers' occupa-

tional health and safety and for the acceptance and mitigation of negative impacts of algorithmic technologies in the workplace (Park et al., 2021; Urzí-Brancati and Curtarelli, 2021).

Moreover, when not only instructions but also the evaluation of workers is based on automated data processing by the algorithms the social environment can be affected also by discrimination and by competitive rather than cooperative behaviours. This is especially the case when algorithmic evaluation is employed in recruitment or it is used for contract renewals or for assigning tasks, shifts or bonuses to workers.

Todolí-Signes (2021) explains that algorithmic evaluations rely on the development of workers' profiles and their classification by the parameters defined by the algorithms themselves (i.e. workers' profiling). However, the definition of these parameters, and thus the profiling, may perpetuate existing biases from the data feeding the algorithms, making the workplace and HR practices potentially even more discriminatory than before, as is pointed out in the literature as well.

These evaluation systems, based on pervasive monitoring and surveillance to develop workers profiling, also encourage workers to adopt competitive behaviour. Together with algorithmic management, gamification strategies are sometimes used to embed in the organisational culture this kind of competitive behaviour, to promote productivity-enhancing working methods. The gamified working environment is, by definition, a competitive environment, where workers compete over the performance ranking that is used to exert control and discipline them (Moore, 2020). Even in contexts where team work and cooperation is desirable, such as healthcare or project-based consultancy, workers' interaction might be constantly monitored and thus controlled centrally through the technologies enabling algorithmic management, possibly exposing workers to social pressures (Ito-Masui et al., 2021; Kellogg et al., 2020).

4.3.4 Prospects and earnings

Finally, the blurring of the organisational boundaries linked to the atomisation of labour can affect employment relations, as explained earlier, because organisations could recur more often to subcontracting, outsourcing and crowdsourcing, including through digital labour platforms. More casual and atypical work relationships might be linked to higher job and income insecurity for the workers. These work relationships, when coupled with the process of de-skilling mentioned earlier, can worsen workers' career prospects (e.g. the possibility to find a job after a contract ends) and earnings (e.g. in terms of both remuneration for the present job and possibility to earn in the future).

Delfanti (2019) explains how workers in de-skilled and centrally controlled jobs can be more easily substituted with others in the context of warehouses, when long-term employment relationships are not in place. In addition, Wood (2021) and Kellogg et al. (2020) provide several examples of how the on-demand approach to work that can be fostered by algorithmic management does not provide workers any certainty that they will be assigned tasks or shifts in the future, not even in the short term (e.g. from one day to another). Again, the decisions affecting job opportunities for those subject to algorithmic management can be based on evaluations that rely on automated data processing, which limits the possibility to predict, to contest or to understand these decisions, which may increase the sentiment of insecurity over the job and its remuneration.

All these effects on job quality constitute, in the end, psychosocial and physical risk factors that can lead to consequent disorders and illnesses, both mental and physical, such as anxiety, depression, cardiovascular diseases or muscoskeletal issues, to give just a few examples (Todolí-Signes, 2021). The empirical literature has demonstrated, in fact, an association between technologies that enable algorithmic management and an increased exposure to these risks factors (Urzì-Brancati and Curtarelli, 2021). Again, the impact of algorithmic management on occupational health and safety can be influenced by specific organisational features of the context where it is introduced. For example, the rigidity of physical workplaces, fixed working hours and the digital control associated with the in-person surveillance could increase mental distress about the pervasive monitoring and surveillance that characterises algorithmic management practices (Ball, 2021). On the other hand, pre-

existing procedures and provisions for occupational health and safety could, at least potentially, mitigate negative effects (Urzì-Brancati and Curtarelli, 2021).

To conclude, it is worth noting that, at least in theory, job quality, as well as occupational health and safety, has also the potential to improve with the use of algorithmic management practices. In effect, algorithmic management as defined in this paper, has to be understood in general, as a socio-technical process. Therefore, managerial algorithms should not be assumed as positive or negative *per se*, and their effects cannot be predicted ex-ante. The final outcomes of algorithmic management on job quality would instead depend on the choices, both institutional and organisational, on how to use algorithmic management practices, for what purposes and to achieve what goals.

5 How could algorithmic management be regulated and beneficial for workers? A discussion of policy options

The digital era at work comes with the collection of massive amounts of data and a perceived loss of clear boundaries between private life and work organisation. During the pandemic, the recourse to technologies for remote monitoring and surveillance increased. For instance, new tools were used to control whether workers follow the procedures linked to Covid-19 containment measures, such as wearable devises measuring social distance or cameras combining facial recognition, temperature measurement and mask detecting systems. The increase in managerial prerogatives that followed the introduction of such measures was rarely accompanied by legal policies to protect workers autonomy nor to limit employers' power, resulting in the emergence of new power dynamics in the workplace. In this context, the rapid expansion of algorithmic management in regular workplaces poses new questions about how to ensure the right balance between the respect of workers' fundamental rights and the employers' rights to exert control over the workforce. To balance power relationships in the workplace we need to engage in a critical analysis of the tools that technology puts at our disposal. New rules for access to data and algorithms can play a critical role in dissipating the asymmetry and in this section we discuss some policy options about how algorithmic management could be regulated and beneficial for workers.

A critical issue is to understand how data are collected and used, and to whom the use of algorithms and predictive analysis tools could be beneficial and under what circumstances. The analysis so far has extensively discussed and described how algorithmic management affects several aspects of working conditions in different work contexts. To govern the digital transformation at work both data and algorithms should be regulated and, also, the notion of 'worker' must be revised in a digital context, considering the impact of new technologies in terms of monitoring, surveillance, profiling and determining the social conditions inside and outside the digital sphere. The notion of 'digital worker' could encompass the worker's right to self-determination in the digital space. That would allow workers to define the type of control they have over the data and to gain back power over the determination of the processes and of the self in the digital space.

The concept of digital workers' self-determination should focus on the necessity of empowering the data subjects (i.e. the digital workers) to oversee their digital image and to take control over its use. In the context of work, this would translate in giving workers access to the data they produce while executing their work, and recognising them the right to be informed about the data flow and data value chain, and the right to control and influence which uses of data analytics are legitimate for management purposes. In this sense, the right to self-determination of digital workers does not refer to an individual but rather to a collective as the subject of this right. In other words, the right of digital self-determination is a pre-condition for the implementation of collective rights for digital workers with the aim of addressing regulatory gaps and negotiating working conditions, including workers' data rights in companies and organisations.

The discussion about workers' data rights and allowing access to data and algorithms needs clarification on certain aspects. First, the nature of data that is being referred to needs to be clarified, that is, workers' personal data or any data collected at the workplace or during work execution. This

aspect already poses some difficulties on the threshold to be set between what could be considered personal and not personal data, and whether data transformations (i.e. aggregation, anonymisation, etc.) could be accepted as a sufficient protection of the use of individual data. Secondly, workers' data rights may encompass different stages of the data value chain, therefore it must be assessed to which phases data rights should be attached (collection, analyses and inferences, storage, etc.) and for each step of the cycle the attached rights should be determined and, most importantly, made enforceable. Thirdly, it is critical to establish by whom and how access to data and algorithms should be regulated.

5.1 A policy option for regulation of data and algorithms in the labour market

A simplified way of looking at the role of data in algorithmic management is to divide the process into three steps: i) input, that is data collection, data manipulation, data training; ii) inference, that is the definition of parameters and metrics, machine learning functions, optimisation loops, analysis loops, etc. (the so-called Black Box) (Pasquale, 2015) and iii) output, that is the final decision (Aloisi and De Stefano, 2022; De Stefano, 2019; Gillespie, 2014). The policy option to regulate the use of algorithmic and AI empowered systems in the labour market should consider all the different aspects that concur to the realisation of the outcome.

The legislative initiatives so far have focussed on aspects of the process separately (i.e. protection of personal data, risk-based assessment of AI applications, output discrimination, etc.), without providing an encompassing framework for digital workers. The European directive proposal on platform work[9] may represent a first attempt to regulate algorithmic management in a consistent framework, although it only covers workers mediated by digital labour platforms. The proposal dedicates a full chapter to algorithmic management and aims at ensuring fairness, transparency and accountability by introducing the right to transparency regarding the use and functioning of automated monitoring and decision-making systems and by ensuring human monitoring of the impact of such automated systems on working conditions and health and safety at work.

At the same time, some knots need to be untangled, particularly on the overlaps and coherence between the directive proposal, the proposal for AI regulation (hereafter AI Act) and the General Data Protection Regulation (hereafter GDPR). Although the proposal on platform work introduces two very important principles, the transparency and explainability of algorithms used at work and the human-in-command approach, there is however, no explicit reference to data access, and it does not clarify who should be held accountable when the AI provider does not coincide with the employer or the platform. Furthermore, both the AI Act and the directive proposal do not consider explicitly the impact of algorithms on working conditions, and they do not foresee the possibility of prohibiting the use of automated systems in particular situations, such as workers' dismissal. However, the proposal does extend some individual rights, established by the GDPR, through the definition of channels for discussing and requesting review of automated decisions and by introducing collective rights regarding information and consultation on substantial changes related to the use of automated monitoring and decision-making systems.

The information rights introduced by the directive proposal build on and extend existing safeguards in respect of the processing of personal data already established by GDPR. Nevertheless, some of the critical issues of GDPR remain. First, one of the main problematic features of GDPR is consent: whereas it seems that most of the limitations introduced could be circumvented by the explicit consent of the data subject, it is legitimate to wonder how consent should be interpreted within an employment relationship. The jurisprudence in different countries ruled in favour of interpreting such situation as devoid of 'free consent', as it can be strictly necessary to the fulfilment of the contractual obligations of employment. Secondly, workers' personal data are already under GDPR protection, and extending these rights from the individual to a collective subject increases the real

[9] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0762

possibility of making this regulation enforceable. However, it does not clarify what rights workers may exert on those data that technically do not fall under the umbrella of personal data, although still resulting directly from workers' activities or data collected by employers under administrative obligations.[10]

While data has taken an increasingly central role in the public debate and academic literature on the future of work, most of the attention has been around personal data and the breaching of boundaries in surveillance and monitoring practices, a concern that dates back to the first wave of computerisation, as exemplified by the 1997 ILO Code of practice on the protection of workers' personal data. The Code was produced on *"[…] the conviction that the systematic collection and retrieval of personal data has far-reaching consequences. The gathering of a large number of data and the many different uses to which they are put not only multiply the risk of false or misunderstood information, but also permit close monitoring of the persons concerned and intensify tendencies to influence or even to manipulate their behaviour. The less, therefore, that the persons concerned know about who is processing which data for which purposes, the less they are able to assess their individual situation and to express and defend their interests: in short, they have difficulty in determining their own personal development. The quest for principles to govern the processing of personal data expresses, therefore, the need to protect human dignity."* (p.8, ILO 1997). On the contrary, less attention has been devoted to non-personal data and to analysing alternative forms of data governance and workers' data rights that could help empowering workers and trade unions. Moreover, nowadays the capabilities of employers to collect, analyse and organise data has reached such advanced levels of complexity as to potentially transform the role of the company itself as technology organisation or even a data intermediary. A reality that may expose workers to greater vulnerability in situations where the current institutions and legal frameworks cannot provide adequate assistance and control.

5.2 Establishing data rights to empower workers control over algorithmic management

As a first step, individual and collective worker's data rights should be determined so as to facilitate the self-determination of digital workers and confront power asymmetries over technology and data control in the workplace and the labour market. Colclough (2021) suggests for a *digital new deal* which stresses the importance of addressing the existent regulatory gaps and negotiating for workers' data rights as a prerequisite to reach 'collectivization of data and an alternative digital ethos' to offset the digital power asymmetry of the labour market. As workers' data rights encompass different stages of the data value chain, we discuss policy options of how the different stages involved in data processing and algorithmic management could be regulated.

The first stage of the data value chain is collection of data. The data collection phase can include sources of data both internal and external to the workplace, as well as data that are collected by the employers under administrative obligations or automatically generated training and validation datasets (see Uber's Generative Teaching Networks project). Normally these types of data may be personal, non-personal or a combination of both. Trade unions, workers or their representatives should be informed about these data collection processes. This would include the way data are collected (or produced in case of automatically generated training data), for which purposes and about which aspects of the employment relationship (i.e., during hiring procedures, work execution, etc.). Furthermore, workers and trade unions should be given access to the same data. The legal rights attached to the data collection phase should, however, go beyond a pure information right

[10] It should be noted that in current intellectual property frameworks, in many cases any data produced by employees as part of their work belongs to the employer. Generally, employees have no say on how the factors of production are used, including sometimes the intellectual property they generate. Thus, the ongoing discussions about data ownership in the context of algorithmic management brings into the fore a key legal and political clash between personal data protection and privacy on the one hand, and intellectual property and contract law on the other.

but also should assure that each worker is provided with a Data Protection Impact Assessment (DPIA), as established by the GDPR, to identify the risks arising out of the processing of personal data and to minimise these risks. Workers and trade unions should have the possibility to reject the use of specific tools of collection and refuse or forbid the collection of data, holding the management accountable for a definition of an ethical code for data collection in line with anti-discrimination laws and control over quality data input. Similarly, workers should have a say on for how long, for which purposes and where the data collected are stored. Data storage plays an important role as for example data may be stored in countries that do not allow access to foreign authorities, or on the contrary, as in the case of the U.S. Cloud Act, data held by U.S. providers everywhere should always be made accessible to the U.S. government upon request, creating additional obstacles to national authorities and local stakeholders in exerting full control over workers' data, for example in case of dispute resolution or legality review.

The second stage of the data value chain is data analytics. The data analysis phase consists in making the data acquired amenable to use in decision-making processes by extracting the relevant information, modelling the data and defining the rules and the criteria that run the algorithms that produce the inferences about workers behaviours, work execution and so on. While these inferences define how workers are managed, evaluated and disciplined, workers are often unable to predict, understand or refuse it, and it impacts their everyday working life and their right to self-determination. For instance, these inferences can define working schedules and practices, payment and wages, promotion and hiring as well as disciplinary sanctions or even dismissals. Borrowing the concept of 'a right to reasonable inference' (Watcher and Mittelstadt, 2019) from the data protection law and extending it to labour rights, would allow workers to have the entitlement to a certain degree of explainability of the algorithms, giving them some agency over the algorithms and AI systems with which they interact, so that they have practical knowledge about them and are able to contest them. The metrics and the rules governing the algorithmics should be transparent and accessible to all relevant stakeholders (i.e. workers, trade unions, national authorities) and governments should enforce measures to foster a participatory and cooperative decision-making process between workers and management. Moreover, not all automated decisions should be permitted. Algorithms that can be used to dismiss workers or that are the *de facto* sole decision-maker about workers should be prohibited (Ponce del Castillo 2021). A participatory approach, such as co-determination in the definition of the use of algorithms at work, can help rebalancing the negotiating power between workers and employers by preventing abuse of contractual disparities and shield workers from unfair employment terms imposed by a party with a significantly stronger bargaining position.

Finally, workers should also be concerned with the management of their data and inferences if those are used by employers for lucrative purposes. As already mentioned, the accumulation of data that takes place in companies can transform the role of the firm itself as technology company or at least data intermediary. The data and the inferences produced or collected at work may be sold or passed to third parties to monetise and create revenues over employees' profiles, work organisation datasets and other forms of aggregate and structured information. The data monetisation phase should be controlled and regulated, and both workers and trade unions should have an active part in the negotiation with the aim of redistributing a share of the data value created to workers and society.

Trade unions and workers' collective organizations could also consider moving from an individualised asset-based understanding of data control to a collective system based on rights and accountability, with legal standards upheld by a new class of representatives who act as fiduciaries for their members. The next section describes how such a system could be made operational.

5.3 A public data trust for workers?

Algorithms and data are at the core of an ongoing process of platformisation of work. The techno-deterministic view of the future of work creates a narrative where labour precariousness, increased

surveillance and labour market deregulation are the only way to keep the model sustainable and foresees universal basic income (UBI) as the new way to balance the inequalities.[11] However, the future of work could also be oriented towards regulating the exercise of power, by making data and algorithms open and transparent. This implies creating the digital and legal infrastructure to allow for workers to build collective power, to be aware about new technologies and algorithms and to use them to pursue social aims and collective benefits (De Stefano, 2019).

As a way forward to create awareness and empower workers, the earlier section defined the data rights workers should be entitled to and emphasised the importance of increasing the transparency of algorithmic metrics and functioning. However, it is difficult to access to the source code of algorithms as they are protected by trade secrecy laws and by intellectual property rules at the WTO level (ILO, 2021), which de facto leaves workers with no leverage in case an algorithm is producing discriminatory outcomes. In this context, regulators should intervene introducing legal mechanisms and public digital spaces where data subjects and data collectors, both workers and companies, can negotiate data and algorithms by means of an independent intermediary. These intermediaries could be both expression of bottom-up empowerment structures or could result from the intervention of national authorities, and, potentially, could come in the form of a Data Trust (ILO, 2021; Singh, 2020; Rani and Singh, 2019).

The framework regulating the Data Trust could aim at pooling together workers data to directly address the power asymmetry deriving from algorithmic management. The functioning of the Trust would be based upon a direct transfer of the data rights from the workers to the Trust based on the constitutional terms, which could represent a step towards the beneficial use of algorithms for workers to ensure decent working conditions and workers data protection. The purposes of the Data Trust would have to be well-defined and reflect the pursuit of the interest of the beneficiaries (i.e. the workers). A Data Trust could serve for holding management accountable for the use of algorithmic systems and the procedures undertaken to control and eradicate bias and discrimination.

The Data Trustees, that is the board members governing the Trust, could be direct representatives of workers, trade unions or even third parties bound by a fiduciary agreement to the beneficiaries of the Trust, and could negotiate on workers' behalf data use and algorithmic management practices. Ideally an ecosystem of Data Trusts specific to different kinds of situations and following different purposes, but able to pursue a common societal aim, could address power asymmetries, reduce inequalities and in turn benefit workers, who would gain back bargaining power. A more balanced negotiating power could be a direct consequence of pooling workers' data rights together and acquire control over their use and the use of algorithms. A potential purpose of the data trust could be to verify or audit the accuracy and correctness of the metrics and parameters ruling the algorithms that define working conditions, without breaching trade secrets rules nor revealing the source code.

This policy option illustrates a possible way to redress the asymmetries and imbalances that can be created by the widespread collection of data on the work processes and the utilisation of algorithmic management practices. Data Trusts as well as other forms of collectivisation of data can be the tools to modernise and restore democratic participation in a labour market that is undergoing the digital transformation. Workers' data collectives build on the recognition of workers' data rights and on making these data accessible. Furthermore, governments should prompt the development of data collectives' ecosystems ensuring that data are portable and erasable to assure a more balanced labour market and redistribute the value of technological progress. Data should be regarded as a public good and trade unions should access both data and algorithms and become active part of the algorithmic governance at work. Co-determination of technological changes should be encouraged in the workplace, to guarantee a fair digital transition for all workers.

[11]As for example the endorsement by Big Tech of proposals for the introduction of the Universal Basic Income, Sadowski, J. (2016, 22 June), "Why Silicon Valley is embracing universal basic income", in the Guardian.

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List of abbreviations and definitions

AI	Artificial Intelligence
BPO	Business Process Outsourcing
DLP	Digital Labour Platform
DPIA	Data Protection Impact Assessment
GDPR	General Data Protection Regulation
ILO	International Labour Organisation
IT	Information Technology
ICT	Information and Communication Technology
HR	Human Resources
UBI	Universal Basic Income
US	United States
WTO	World Trade Organisation

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