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SPECIAL ISSUE PAPER

Digital worker inquiry and the critical potential of participatory worker data science for on-demand platform workers

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Abstract

The knowledge that workers have of the systems they work under is an outcome of strategic choices by platforms and by workers themselves. Based on three initiatives undertaken by food distribution workers in Scotland, this article explores the obstacles that platform workers face when conducting inquiries into their systems of control, and investigates the potential for workers to overcome these obstacles through collaborative research projects. By drawing analogies from the history of workers' inquiries into changing labour processes, the article evaluates these three initiatives in light of previous efforts by workers to monitor complex and concealed management structures. It offers a new concept of 'worker data science' to describe the techniques, skills and methods that workers require to arrive at answers to questions that emerge through their inquiries, and concludes that such purposive science has the potential to equip workers to support one another and to resist and challenge some of the commands and calculations that emerge from platforms' hidden algorithmic systems.

KEYWORDS

citizen science, data rights, digital skills, Gig economy, platform work, trade union, union organising, workplace control

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INTRODUCTION

The knowledge and experience of on-demand food delivery workers is shaped by the algorithmic management systems that organise and control their labour processes. Knowledge of the technical operation of platform-based technologies that govern their labour is more likely to be held by social scientists and data scientists than by workers on the ground. While a range of initiatives across the world have sought to give workers more knowledge of these systems, recent scholarship (Dubal, 2023, p. 10) suggests that workers' 'attempts at [attaining] transparency' may not yield the material benefits they hope. Yet the history of workers' responses to changing labour processes suggests that workers have always inquired into systems of control and monitored rates of pay (Sonenscher, 1989; Thompson, 1967; Truant, 1994) and that those workers who come to hold and share knowledge about systems that control their labour processes are more empowered to resist the degradation of work (Braverman, 1998), and to orchestrate and realise longer-term interventions or organising strategies for improving their rates and conditions (Noble, 1984). Through the lens of this labour history, and guided by recent writing on the potential of forms of digital workerism (Woodcock, 2021a) by which digital workers might free themselves from aspects of algorithmic control, this article explores a set of cases of local digital worker inquiries among on-demand food couriers in the East of Scotland. We show how qualitative and computational inquiry has enabled these workers to gain some insight into and control over labour processes, while also setting out the limits and challenges of these inquiries.

Certain tacit knowledge about the operation of platforms is, of course, inherent to on-demand courier work. Given that platforms rely on revolving labour pools, often composed of migrant workers (Lata et al., 2023), on-demand couriers in the city are continually teaching themselves and each other how best to use food delivery apps. Essentially, riders must learn how to adapt platform services to the local environment (Gregory & Maldonado, 2020) and acquire new 'spatiotemporalities' that enable them to navigate and map delivery zones, while also learning to speed up their work to meet app demands (Wu & Zheng, 2020). Workers must also absorb 'middle management tasks' such as managing and maintaining their working equipment and learning to bear the costs of operating as self-employed workers (Enriquez & Vertesy, 2021). As such, much of this tacit knowledge of how on-demand apps operate is learned through the negotiation of personal risk and efforts to stay alive while responding to the incentives that apps provide to deliver food or other goods as quickly as possible (Gregory, 2021a; Gregory & Maldonado, 2020). Additionally, tacit knowledge of algorithmic management systems develops through workers' own informal conversations as they work (Galière, 2020), as well as through concerted attempts to inquire into and understand their working conditions, for example through collective inquiry in Whatsapp chats, social media forums, or organising meetings (Woodcock, 2021a). Much like Gray and Siddharth (2019) have shown of crowdworkers, on-demand couriers work together to learn how to work under, with, and in certain cases against the demands of the app.

On-demand couriers can only learn so much about the operation of platforms through sharing their tacit knowledge. They do not have access to the data that platforms use to distribute orders, calculate rates and allocate routes. Their knowledge of their own labour processes does not reveal the data or decision-making formulas on which platforms operate. By treating these workers like bits in broader logistics systems (Richardson, 2020), platforms create new 'efficient' delivery routes and ways of negotiating the environment (Vallas & Schor, 2020) that supplant the knowledge of routes and navigational flows on which workers had depended.

These incoherent shifts in the place, space and experience of on-demand work have prompted considerable resistance among on-demand couriers (Tassinari & Maccarrone, 2020), akin to resistance by other kinds of platform workers across the globe (Cini, 2022; Joyce et al., 2020; Woodcock, 2021b). While much of this localised resistance has coalesced around demands for employment recognition, wage security, and improved health and safety standards (Johnston & Land-Kazlauskas, 2019; Wilkinson et al., 2022), in some cases on-demand platform workers have also agitated for clearer insight into the algorithmic command and control systems that alter their work and the knowledge used to undertake it (Attoh et al., 2019; van Doorn, 2020b; Safak & Farrar, 2019). For on-demand food couriers, key concerns about the ‘calculative asymmetries’ that shape working conditions (Shapiro, 2020), particularly those that shape ‘dynamic pricing’ policies (van Doorn, 2020a) or what Dubal (2023) rightly labels ‘algorithmic wage discrimination’, have given rise to demands for knowledge about platforms’ systems of operations and control.

While on-demand workers are often dubbed ‘the future of work’, their demands to understand platform operations can be regarded as part of a larger historical pattern of inquiry that takes place when generations of workers encounter new mechanisms and categories of control that do not accord with their residual knowledge about the labour process. In E. P. Thompson’s classic account, when factories began to be tightly regulated by clock-based schedules, workers were not necessarily clock-literate, sometimes lacking knowledge of clock-time. Over time, however, workers increasingly took watches into workshops to monitor their own hours and shifts, to discern when masters attempted to manipulate time-measuring devices to their advantage, and to form demands relating to the precise length of the working day (Thompson, 1967). Data-driven technologies underpinning platforms represent equivalent shifts in the technologies of workplace control. From cock to clock to code, the history of modes of measuring and organising work are paralleled by histories of workers’ efforts to monitor and understand new systems, to inform their interventions and organising efforts. Whenever new technologies are introduced, some workers who are subjected to them—perhaps only a fraction—endeavour to gain insight into systems that control them. Clearly, food distribution workers are no exception. What remains unclear is the potential for on-demand couriers to obtain useful knowledge of the technical systems that are used to control them; knowledge that, on the one hand, might empower workers to make better and safer choices in their day-to-day work, and on the other, might allow workers to collectively exert power through pooling their insights. It is clear that workers who do attempt to gain insight into platform systems face considerable obstacles in using that knowledge to enact long-term change or broader regulation. Yet just as these obstacles are deliberately erected by platform masters—who withhold information from couriers (Franke and Pulignano, 2021), for instance, or erratically alter their routes and routines (Muldoon and Raekstad, 2022)—workers make their own strategic choices as to how to empower themselves to remove or overcome them.

Writing as a team composed of a union organiser and historian, an academic, and an experienced on-demand courier, our article explores the potential for the pursuit of knowledge about platform-based control to increase some workers’ power to improve their experience of work. It does so by analysing three experiments undertaken through the Workers’ Observatory (WO), a collaboration between workers and researchers based in Edinburgh, Scotland’s capital, which since 2020 has been designing and implementing local interventions into platform work based on organised gathering of collective insight and acquisition of worker data alongside more traditional forms of worker organising. We take up the WO case study to examine how different kinds of knowledge—both specific to their locality and general to the platform—are

being developed and mobilised by workers in the on-demand food delivery economy. Through the Observatory, workers meet one another, discuss working conditions, share information, and develop best practices for negotiating risks. Alongside these knowledge-sharing activities, as part of a broader project of organising, these workers discuss the algorithmic function of the platform itself, developing ways to access, aggregate and analyse platform data to gain insight into working patterns that can empower them individually and collectively to better their labour conditions. In short, these workers are engaging in a form of purposeful digital worker inquiry (Woodcock, 2021a), which combines insights drawn both from their own experiences of work, and from the results of their experimentations with a range of methods and mechanisms for increasing their understanding of how algorithmic technologies are used to manage them.

These inquiries do not align neatly with the two main angles of research concerning the impact of algorithmic systems on workers. One broad approach uses labour process theory and other methods of industrial analysis to examine the choices and functions that platforms make in the process of exerting control over workers (Franke & Pulignano, 2021; Gandini, 2019; Shapiro, 2020). Another broad approach considers algorithmic management through qualitative studies of workers' experiences and perspectives to illustrate the effect of algorithmic systems on the quality of their work, the nature of their conditions, and their degree of control and capacity to resist (Griesbach et al., 2019; Mendonça & Kougiannou, 2022). This rough binary reflects an older divide between studying 'the objective conditions of the labour process and the subjective mechanisms of control and subordination' (Heiland, 2021). Our case, however, is part of a recent trend where workers are drawing these two paths together through the design and development of data-driven tools (Gregory, 2021b). Here, workers' interest and capacity to develop a tool becomes an inherent part of the inquiry process—it becomes the ground of experimental learning, whether or not the tool is a success.

Our interest in this case is twofold. First, we are interested in the potential for such tools to offer workers some autonomy and agency 'in the here and now' (Woodcock, 2021a, p. 96). Given that on-demand couriers are currently misclassified as self-employed contractors and their work remains risky if not deadly at times, we see both tool development and the outputs of tools (such as tools for pay tracking, visualising working conditions, or monitoring downtime and unpaid or underpaid time) as one potential form of support. Such support can help workers to make better-informed choices about when and how to work. Second, we want to build on the understanding of algorithmic technologies as social and relational systems rather than static systems of control. Consideration of the social-shaping of technology (MacKenzie & Wajcman, 1999) can extend to the question of where data science practices sit in the tradition of worker inquiry. While Woodcock (2021a) is rightly wary that a focus on probing into algorithms and building the capacity to 'reverse engineer' (92) risks drawing focus away from the emancipatory potential of technologies that workers already have at their disposal, such as communication technology like Whatsapp, here we show how demands to be 'shown the algorithm' come out of qualitative inquiry and are evidence of platform workers' desire to understand their working conditions. In many ways, these workers are extending a broader cultural interest in algorithms as objects of analytic attention (Dourish, 2016). Furthermore, we show how the demand 'to be shown' the technical backend of platform systems in fact expresses and encapsulates workers' desire to answer myriad work-related questions that workers often feel can only be answered through accessing 'data' and by generating 'proof'. Given the obstacles facing workers who attempt to access such data, we see value in workers engaging in critical debates about which kinds of knowledge matter for their efforts to improve their labour conditions.

Before we proceed, it is perhaps helpful to illustrate the kind of potential we mean. A key issue for on-demand food distribution workers is ‘dynamic pricing’ and wage fluctuations. Obviously, these often make life a misery. A certain amount of qualitative information can be gathered and shared through the use of communication technologies, but when workers want to know the formulas and logics behind fluctuating rates, this process of inquiry hits a barrier. At this stage, workers might decide whether or not to gather new data. They may consider what technologies, skills, and abilities they have among themselves or need to access and analyse this data. As we shall see, these questions do not undermine, but rather strengthen, the agency and autonomy of workers and their capacity to form integrated and active networks (shaping their ‘class composition’). However, the need to develop, or work with those who have, computational or data science skills is also a challenge for platform workers. Here, data raises not only issues of knowledge, but also of unequal power dynamics in partnerships and collaborations.

To explore these issues, we organise our article as follows. First, we show how aspects of the nascent efforts of platform workers to obtain useful knowledge may usefully be situated in the context of certain historical precedents, such as the premium placed on workers’ shared and collective knowledge by 18th-century couriers, the efforts of 19th-century factory workers to reverse-monitor factory owners who used clocks to reform schedules, and the way that 18th-century craft guilds systematically observed data about wages within and across towns to demand and establish their own local rates. Then we turn our attention to the WO, to explore through a detailed case study how processes of ‘digital worker inquiry’ have led workers from qualitative knowledge-sharing based on universally accessible technologies, to the formation of new techniques, data analysis skills, and technologies to enable them to deepen their knowledge in ways they hope to be empowering. We introduce the term ‘worker data science’ to point to the use of new methods which may, within limits, be taken up by workers to empower themselves to organise and intervene in platform working conditions.

TRANSNATIONAL PLATFORMS AND THE REDUNDANCY AND DISORGANISATION OF LOCAL KNOWLEDGE

Food delivery platforms use a flow of proprietary data gathered across transnational networks to create algorithms that control labour processes wherever they operate (Wood et al., 2019). As a range of logistics technologies now shape delivery labour of all kinds (Ness, 2023), the erosion of workers’ residual knowledge and the prevention of insight into controlling algorithms contributes to an information asymmetry between platforms and workers (Rosenblat & Stark, 2016). For instance, GPS tracking services which dictate and watch delivery routes trump worker knowledge of efficient and safe routes, and failure to adhere to tracked routes can result in deletion from the platform (Livingston, 2022). Performance metrics also dictate working conditions and determine workers’ ability to continue working via the platform, in effect operating as a workplace authority capable of determining when workers are able to work as well as when workers are ‘deleted’ or terminated from the platform. Such algorithmic management entails the acceptance of what Popan (2021) has called a ‘calculative rationality’: a willingness to abide by the constraints placed on worker agency and knowledge. According to this rationality, it is accepted that data ‘knows’ how best to allocate and manage work. A fundamental condition of working as an on-demand courier is ceding personal and local knowledge to the functioning of logistics software.

The erosion of knowledge that results from new platform technologies amounts to a process of deskilling, devaluing and potentially degrading labour. This phenomenon can be situated in a historic trend where knowledge that workers require for the work process is gradually broken down, as articulated in Harry Braverman's (1998, p. 319) description of the degradation of work as:

the incessant breakdown of labor processes into simplified operations taught to workers as tasks. This leads to conversion of the greatest possible mass of labor into work of the most elementary form, labor from which all conceptual elements have been removed and along with them most of the skill, knowledge, and understanding of the production processes. Thus the more complex the process becomes, the less the worker understands. The more science is incorporated into technology, the less science the worker possesses.

Braverman was writing about the kinds of technical and bureaucratic knowledge that was made redundant by systems of production and workplace control characteristic of 20th-century manufacturing and clerical work. In the case of food delivery, platform technology incorporates the kind of knowledge that workers have for centuries used in local distributive labour processes. Workers are dispossessed of a 'science' that involves logistical, geographical, and social knowledge. The exclusive value of a courier's skills once included knowledge of how best to navigate the city; of what work is worthwhile and attracts a fair price; of who has the experience and insights to help them increase their knowledge; and of which relationships to sustain to maintain their knowledge. As systems evolve, such knowledge erodes. Data-driven platforms have thus resulted in a deep and permanent change in the knowledge required to carry out distribution work, and thus, in Braverman's terms, in the dispossession of a 'science' that was learned, sustained, and shared through the work process. The erosion of such knowledge also weakens workers' autonomy and capacity to organise and control their own labour process. In other words, knowledge required both to undertake work autonomously and to organise work collectively implies knowledge of the systems of control under which you work.

This doubly empowering effect of knowledge in courier work is illustrated in the case of the Society of Cadies, the association of couriers in 18th-century Edinburgh. Its members delivered parcels, food, messages, pamphlets, and other goods around the city, as well as carrying out other odd jobs. Working independently, but sharing knowledge, cadies 'execute[d] suddenly and well whatever Employment [was] assigned them' (Burt, 1754, p. 27). Indeed, since they had more knowledge of the city than the local authorities did, they were sometimes asked to carry out policing functions, and as they ran errands and made deliveries, they amassed and shared ever more information, all of which increased their value to customers as well as their autonomy. They had a reputation both for independence and for being 'the only persons who may truly be said to have attained universal knowledge, for they know everything and everybody' (Topham, 1780, pp. 216–217). Extensive knowledge of Edinburgh is obviously not unique to eighteenth-century gig workers and it is still prized by Edinburgh cab drivers (McCulloch, 2004).

Such detailed local knowledge is no longer a prerequisite for on-demand food distribution work. As data and algorithms step in as 'the boss', the platformisation of courier work entails a fundamental and permanent change both in the knowledge required to work and the knowledge workers have of how their labour processes are organised and managed. The change

is fundamental, because much of the basic knowledge that was formerly couriers' source of value, their knowledge of the city, is rendered redundant by the introduction of app-based technologies. It is permanent, because the lost knowledge cannot be restored. The maintenance of tacit knowledge, whether of cities or of systems, depends on using it in practice; it cannot be learned back from platforms. Indeed, even if workers could access the data that directs their work, the data that transnational platforms require to make their algorithms locally applicable does not necessarily mirror the local knowledge that workers relied on to carry out their work. Indeed, since the local knowledge that becomes redundant for workers is not necessarily preserved in platforms' data sets, much of the knowledge that gave the work its value is no longer possessed by anyone. Consequently, even the best efforts to gain insights into the data used by platforms could only ever reveal or restore a fraction of the local knowledge that formerly gave work its value or shaped its organisation. We shall return to the question whether attempts to obtain some of this knowledge are viable or valuable. What is clear is that data-driven platforms have resulted in a deep and permanent change in the knowledge possessed by those who carry out distribution work, and thus, in Braverman's terms, in the dispossession of a 'science' that was learned, sustained, and shared through the work process.

WORKERS' KNOWLEDGE AND THE REVERSE MONITORING OF CHANGING WORK

While new technologies result in the erosion of knowledge, they often also precipitate efforts by workers to monitor their changing experiences and share their perspectives of new technologies, the skills required to operate them, and the effect they have on conditions and pay. Knowledge informs organising, particularly at a time when 'new new technology' (Howcroft & Taylor, 2014) is introduced but workers do not understand how it operates and lack the capacity to monitor it. The effort to inquire into workplace processes is often triggered by a change in the technologies at work, particularly when those technologies relate to systems of centralised control.

Noble (1984) described in detail the way that workers' efforts in the mid-1960s to monitor new technologies at General Electric (GE) in aircraft engine production at Lynn, Massachusetts, equipped their union, the GE Local 201 of the International Union of Electrical Workers, to orchestrate resistance in their interests. GE management attempted to introduce numerical control (N/C), the automated control of machining tools, as part of a strategy to increase managerial oversight of production, improve efficiency, and reduce wages. However, the cost-effectiveness of the new technology was dependent on the skill and judgment of the workforce, leading to what Noble calls the 'central contradiction' of N/C use:

[I]n its effort to extend its control over production, management set out to deskill, discipline, and displace the very people upon whose knowledge and goodwill the optimum utilization, and thus cost-effectiveness, of N/C ultimately depended. (269)

Management expectations of increased efficiency and reduced rates were not achieved because workers resisted management's efforts to deskill, discipline, and displace them (Noble, 1984, p. 266). Workers gathered two kinds of knowledge in preparation for this resistance: knowledge of the new technologies and the skills required to operate them; and knowledge about 'rates juggling' that was being used in an attempt to encourage individual

operators to produce more (Noble, 1974, p. 273). By monitoring the functioning of new tools, as well as the fluctuating rates that were being paid, workers backed up their demands with knowledge of both the new technology and new system of setting rates that were being introduced. Under pressure of a strike, GE agreed to re-evaluate its rates. Alongside efforts to monitor the skills required for technologies, workers' efforts to monitor juggling rates and the slippage of standards of pay empowered their resistance.

These wage fluctuations bear some analogy to the shifting wages among independent artisanal workers in 18th-century France. According to Michael Sonenscher (1989, pp. 177–178), as journeymen moved incessantly 'from shop to shop and town to town', they shared knowledge of pay rates, giving rates a 'collective character' even where workers had no formal collectivities. Their sharing of knowledge contributed to the formulation of fair rates, which in some cases were formally agreed in towns, although they 'were not necessarily the rates that were paid'. Through both deliberate and casual sharing of information about rates which 'was easily obtained and widely disseminated', information was amassed based on the experience workers had of their own and others' pay, which allowed them to monitor rates and fluctuating pay at a city level, and see the discrepancy between rates promised by masters and actual rates received.

THE CHALLENGES OF OBSERVATION DURING BIGGER SHIFTS IN THE SCIENCE OF PRODUCTION AND CONTROL

Data-driven platforms arguably result in a more significant shift in labour processes than the introduction of a new piece of technology into a factory or system of production, or a change in a regimen of pay-rates that destabilises workers' income or introduces new discrepancies between workers. Digital systems running on proprietary data do not simply allow for a series of changes to the efficiency and labour intensity of work; they orchestrate a new mode of workplace control and discipline that affects the ability of workers to know and understand the technologies under which they work. Here, another historical analogy is instructive. Surveying the history of the introduction of clock-based time discipline to large factories, Thompson (1967) observed that at first workers tended to lack access to tools or understanding of technologies that would enable them to monitor and measure changes to their work. He presents cases where the imposition of new systems of time discipline was simultaneous with efforts to expropriate workers of knowledge. A millworker in 1820s England said: 'There was nobody but the master and the master's son who had a watch, and we did not know the time. There was one man who had a watch ... It was taken from him and given into the master's custody because he had told the men the time of day'. Thompson argues that reverse-monitoring of modes of control, even where workers had neither intentions to resist nor strategic initiatives in mind, nevertheless helped the working class to develop technological literacy, compose new rhythms of working to adjust to new systems of time discipline, and respond to changing work discipline in the long term by forming demands on the basis of new technologies: 'The first generation of factory workers were taught by their masters the importance of time; the second generation formed their short-time committees in the 10-h movement; the third generation struck for overtime or time-and-a-half' (Thompson, 1967, p. 86). The shift to code-based control of work, we suggest, represents as significant a shift as clock-based control.

In the context of such a shift, the information or knowledge that is accessible through informal conversation, investigative inquiry and qualitative research can be complemented with knowledge obtained through more technical processes, through creating tools, analysing systems, and developing the kind of knowledge that Braverman calls ‘science’ to replace the science that has been lost. Barriers to workers obtaining insights into technologies or rates are themselves an indication of the fact that more tools and knowledge are needed. In other words: where the attempt at workers’ inquiry does not produce answers, but opens a series of questions that workers lack the means to answer, then this is a case where something more than inquiry is needed. That ‘something more’, we suggest, may be scientific rather than simply inquisitorial or organisational; for instance, it may be computational and quantitative, rather than colloquial and qualitative. Of course, qualitative and computational inquiry must be mutually enhancing and remain grounded in questions that workers raise before and through the course of their inquiry. Simply gathering data for the sake of it will not necessarily answer workers’ key questions.

While we hope that these historical excursions provide illuminating theoretical analogies for the situation of platform workers, they do little to address key questions for digital worker inquiry: How can workers best observe their datafied working conditions? What sort of questions make it useful or necessary to access and analyse proprietary data? What methods are meaningful and worthwhile for workers to engage with? These and other practical questions are being addressed and explored in a range of collaborative initiatives between workers and researchers across the globe that put at workers’ disposal data that enables them to answer questions about their work. The proliferation of these initiatives testifies to the tendency for workers operating under radically new systems of control to pursue knowledge of and insight into the systems that control them. These initiatives can be schematised into three overlapping categories: initiatives where workers gather data themselves through extracting it from the technologies they use; initiatives where workers gather data through experimenting with the capacities of data rights legislation; and initiatives where external parties have equipped workers with means to gather data as they work.

The first category of initiatives facilitates the possibility for workers to gather data themselves either through self-tracking or by turning the information that they receive in the course of working into analysable data. An initiative of this kind was undertaken by the IWGB union in 2019 in their campaign to support food distribution workers in the UK to take a snapshot of their pay over the course of a day. In a similar vein, ‘Contrate Quem Luta’ in Brazil repurposes a Whatsapp Chatbot to share job information and monitor the frequency of work. In the second category, a variety of data-seeking initiatives are mobilising the potential and limitations of data rights legislation to obtain proprietary platform data (Sharp, 2021; Silberman & Johnston, 2020; Stein & Calacci, 2022). Most notably, the London-based project Worker Info Exchange has pioneered tools that enable cab drivers to reacquisition expropriated knowledge through submitting data access requests, which in turn have been the basis for presenting demands regarding platform workers’ status and testing them in court. Geneva-based PersonalDataIO is similarly designing and testing mechanisms, and developing a ‘skills hotline’, to enable and support Uber drivers to get their data (Digipower Academy). In the third category, tools have been developed that provide workers with apps, online interfaces, and other digital means of analysing data and gleaning insights into their working conditions. These include projects that attempt to track working time (The Time Project, WeClock), identify wage theft (Shroma Tool) or underpayment (Coworker Tool), or visualise platform working conditions (Leas). Similarly, the Belgian trade union ACS-CVC has developed an

interface that invites food distribution workers to answer a series of questions that results in information about their conditions (Track My Right). These projects draw inspiration from predecessors such as TurkoPicon, which was developed in 2013 by Lilly Irani and Six Silberman to allow crowdworkers to access and share reviews of employers on the Amazon Mechanical Turk platform.

All of these kinds of initiatives—and we have mentioned only a small sample—involve some degree of gathering and analysing workers' data in order to increase workers' knowledge and power. Besides technical issues of their functionality, and questions about their distribution and dissemination amongst workers, they also raise technical and ethical questions relating to their processing of personal data. Collective efforts to gather data raise challenges in terms of how to steward and store data (Berti Suman & Pierce, 2018), and have led to both theoretical and practical debates about the advantages and limitations of data trusts (Delacroix & Lawrence, 2019) and data commons (Calzada & Almirall, 2020; Wong et al., 2022). They raise questions about the kinds of funding and collaborations that are required to build and maintain data-driven, information-generating infrastructure. Furthermore, as data projects become platform services of their own, questions emerge as to whether they will be accountable to workers in the long term, and might be co-optable by nonworker organisations.

While online interfaces make it easier for workers to request data from platforms and to provide information and data to organisations that can generate insights from it, many workers lack the technological means or technical skills to gather or analyse data from their own labour process or platform interactions. Developing these means and skills would allow workers to form and test their own hypotheses about their work, rather than relying on external parties to do so. Developing methods for workers autonomously to access and build with their data, in a way that frames and answers questions about their work, would form part of developing what we call 'worker data science': the systematic pursuit of answers to questions raised through the process of digital worker inquiry, through processes of experimentation and data-driven analysis. We derive the notion of 'worker data science' (and indeed 'worker science') from the familiar concept of 'citizen science', wherein non-professionals participate and collaborate in scientific projects, especially data collection and monitoring. Certain theorists of citizen science regard it as a way for nonspecialists to take control of scientific projects, answering questions that they want to tackle, designing research methods, collecting and centralising data about their environments, and contributing to the interpretation of results (Wiggins & Crowston, 2011; Wilderman, 2007). Our notion of worker science stems from discussions about radical citizen science, and means the capacity of workers to be in control of research projects about themselves and their working conditions and environments. Worker data science, then, is a form of organised and purposive citizen science with the potential to equip and empower workers to gather, study, intervene in, and modify working conditions through developing the techniques and technologies to answer a series of questions raised through the course of their inquiries.

CASE STUDY: THE WO AND KNOWLEDGE FROM BELOW

We draw the remainder of our article from such an instance of worker data science which developed through the WO, a worker-led research collective established in Edinburgh in 2019 by a group of riders with Deliveroo, supported by a union organiser. With the strapline 'We See The City', the WO's founding intention was to 'watch the city together, to collectively challenge

conditions in self-employed and gig work, to take control of our labour'. Here, we take up the WO as a case study (Hartley, 1994) to explore three participative worker-led experiments that emerged over the course of 2 years. These involved data-mapping, pay-rate data tracking and the building of a data-driven tool for analysing variations in pay over space and time. These methods built on participants' informal sharing of information through chat groups and other social forums, by which workers achieved a more or less accurate grasp of workplace changes and their effects. Each experiment developed from an attempt to inquire into conditions of work, to answer questions they encountered concerning their modes of control and how to resist it. As workers took up each inquiry they identified a set of more specific questions that eventually resulted in a desire to work more technically with data.

Each of the three experiments was worker-led. Each raised questions about how workers can best observe their own conditions of work and organise their own knowledge in ways that are useful to them. The WO operated through regular meetings with rotating facilitators, and through workshops hosted in trade union offices, pubs, bowling clubs, homes, and other venues that were inclusive and accessible, designed around the availability and accessibility requirements of food distribution workers. In a model emulating more radical forms of citizen science, where communities set their research questions and have the support of experts to explore and answer them, union organisers and researchers put their skills at the disposal of workers. This meant that projects had a degree of fluidity and, in some cases, a shifting focus compared with many qualitative academic research projects. Members considered and commenced a variety of projects that did not continue. The three initiatives that we describe here were thus all projects in which workers were sufficiently invested to see them through. Since these projects depended on voluntary activity, workers' own interests constantly informed the direction and development of the projects, and the commitment and engagement of workers to see them through was itself indicative of the degree of interest in them. Where they required complex and technical work of data collection and analysis, workers developed or drew upon their own data skills to contribute to the success of the projects in a voluntary capacity (the exception being the third, more technically complex project, RooParse, whose developer was awarded a modest amount of academic funding to pay for the skilled work of programme design). The workers making decisions about gathering and analysing data did not typically have technical or methodological training. Those with such training played a supportive and advisory role, which stopped short of authorising or guiding the research. The investment of agency with workers, and the prioritising of their objectives and interests, meant that the project outputs never aligned neatly with academic researchers' and union organisers' objectives. While this sometimes resulted in tensions of understanding about the purpose of the research activities, it helped to ensure that the purpose of projects was clear and meaningful for the workers who were participating.

The vignettes below, outlining three experiments, are drawn from participant observation, focus groups with on-demand couriers, and reflective writing done by current WO participants during various initiatives to document their process of exploration. All writing and images appear with the permission of WO participants. While our article relies on descriptive data, together the experiments show the imperative to develop additional methodologies and technologies to confront questions raised but not answered through the process of worker inquiry and worker-led research processes, particularly when workers ask questions that require accessing or gathering proprietary data relating to their lines of inquiry. Furthermore, these experiments allow us to show the limitations of data 'as knowledge' and to illustrate key challenges of accessing, building with and maintaining worker data. The authors took an 'engaged' approach to this research (Milan, 2014), working with participants over an extended

period and supporting them to consider and address workplace concerns and queries. Taking a 'partisan' approach allowed the authors to establish bonds of affinity and trust (see Tassinari & Maccarrone, 2020, p. 42), which better enabled us to understand the complex issues affecting riders, to help them frame questions and problems to be solved, and to ensure that the research process brought benefits for riders in the form of a deeper understanding of their work and ability to make sense of it. Rather than being focused on immediate action, all three projects were designed to contribute to longer-term strategies of knowledge-building and preparation for resistance, through participative activities that gave workers some familiarity and expertise in the data science that underpins their platform labour.

DATA MAPPING: RESPONDING TO THE COLLAPSE OF COLLECTIVE KNOWLEDGE

The first experiment was a *data mapping* project that arose from concerns that workers had around the erosion of the knowledge involved in working as couriers in Edinburgh following the introduction and expansion of the Deliveroo platform, as well as questions they had about the functioning of the platform. In the summer of 2019 a group of Deliveroo riders, including one of the authors, met to discuss their understanding of how their work was shaped and controlled in the city, with a view to formulating demands that challenged the falling rates of pay. This discussion indicated that besides their immediate grievances about pay, workers were frustrated by a dearth of knowledge about how they were managed, and of the way that data and data infrastructures were used to control them. They decided to arrange an initiative to come to a better understanding of how their work was controlled by data and data infrastructures. A group of riders who were interested in this project arranged a data-mapping workshop with the authors.

Riders designed flyers for the workshop and distributed them in hotspots in the city where workers tended to meet between shifts. Six workers attended the 3 h data-mapping workshop that was based on a workshop run by MyData, a data rights organisation. While the group of riders was numerically limited and not an accurate reflection of the workforce, there was significant diversity in their gender, age and country of origin, their levels of engagement with other riders in the city, and their experience of collective organising. Workers were invited to think about the data gathered and generated in the process of their work, from the first time they signed up and signed on, through what happened when they worked, to the end of their work for the platform. They were invited to consider what data is gathered, where it goes, what parties are involved in processing it, and what data or aspects of its analysis would be interesting or useful for riders to know. Workers were asked to 'chart your sense of how your personal data has been gathered or collected by Deliveroo', with the following prompts:

- Think about your work experience from the beginning until now.
- Where does data about you 'live'?
- What parties are involved in processing/using this data?
- Would anything become clearer by multiple workers pooling and sharing data?

The mapping exercise revealed a range of theories that workers had about the organisation of their work. More broadly, it prompted a rich conversation about how riders believed the company was making decisions based on their personal data. It also gave riders a visual and common ground from which to ask questions about how their data is used (Figure 1).

this inquiry to be easily digestible and useful for them and their colleagues, they needed to do more than pool their perspectives. They used their smartphones to screenshot orders, extracted data from the images, performed regression analyses, and formulated and tested a series of rates formulae. This project, carried out over several months in 2021–22, amounted to a collective worker-led project of data analysis to empower workers to press forward with demands for higher rates.

Dunfermline is a small city with a population of around 58,000, in Fife, about 45 min' drive north of Edinburgh. Early in 2021, UberEats workers in the city who had experienced a long term decline in wages, were aware of higher rates in neighbouring Kirkcaldy. They attempted strike action to redress these declines, and made contact with the WO and with another organiser involved with a project called Organising for the Future of Work. These workers were of a quite different demographic from the riders involved in the WO in Edinburgh. Most of them were migrants with families. Most used cars to distribute food, often complementing this work with cab driving. Over late 2021 and 2022, over four 3-h meetings in a bowling club in the city, between 12 and 20 workers discussed how knowledge and data might relate to their efforts at organising around rates. Through discussions about their experiences, comparisons of rates, comparisons of offers they had received, and the sharing of views on the size of the workforce, the phenomenon of dual-apping, and many other factors, the riders reached a series of conclusions about the way the app worked. They concluded from comparing offers that when a rider refused an order, it would often be offered to someone else for a higher fee. They decided that in response to falling wages they would develop a plan to make an intervention that took advantage of this conclusion in an attempt to pressure the local rates to increase. Rather than deciding to reject orders that they personally felt were unfair, they decided to ascertain the average rates that they were currently being paid, and then agree on a rate that they believed to be fair. They arranged to take screenshots of their ride offers during a 3-h window, and to share these, to analyse simple rates of pay.

From the data they gathered from these screenshots, they were able to break down their payments and conduct a regression analysis to identify the average base rate and additional per-mile rate which they were typically paid for delivering orders. When they met at another meeting to discuss the results of collectively generating this data, they had a conversation about how they thought the formula would need to be adjusted to be fair. They each wrote what they thought was a realistic but fair rate for a series of time-distance combinations, and then on the basis of this they created a formula which correlated with their average demands. The formula was $4 + m$ —a £4 base rate plus £1 per mile (expressed in the aide-memoire 'Dun4 + Mline'). They printed this formula on a rates card which they printed and distributed to every driver in the town (Figure 2).

A few weeks later, they arranged another meeting. They distributed a flyer explaining their aims (Figure 3).

At this meeting, attended by 20 members, they agreed that one evening they would reject orders below the rates they believed to be fair. The WO and the Organising the Future of Work organisations arranged for those who rejected orders to be recompensed via a strike fund. Workers carried out the action and a few days later UberEats introduced a modest increase in rates across the board. While there was no way for the riders to know whether the increase was linked to the action, the process generated greater solidarity and commitment within the group. The intervention, supported by monitoring information about earnings through collective inquiry, was regarded as more effective than previous efforts during which workers had 'flown blind'. The drivers had started with an inquiry to identify knowledge gaps they wished to fill

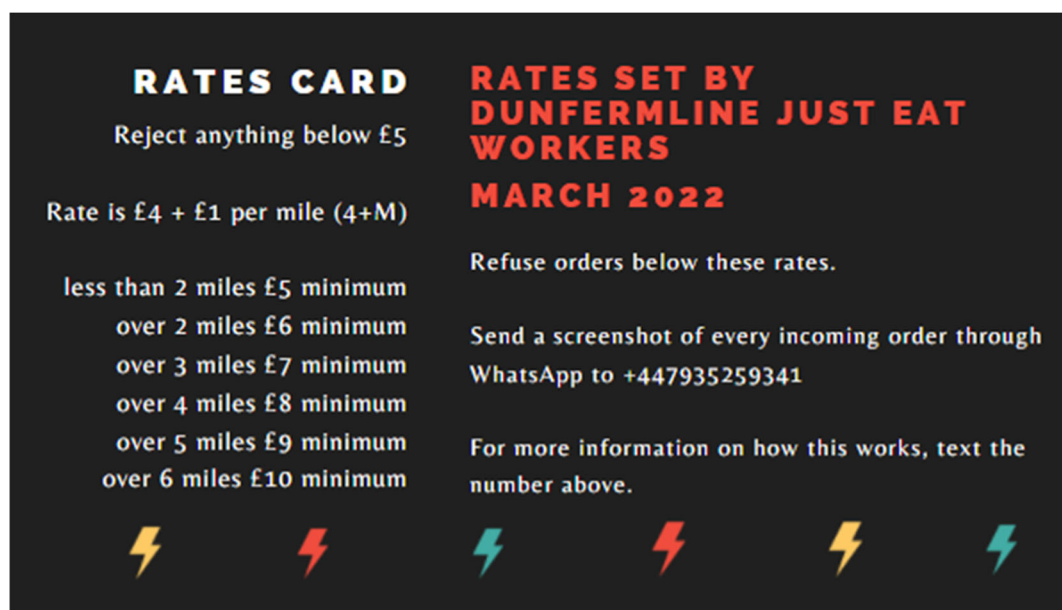


FIGURE 2 Dunfermline workers' rate card (Source: Workers' Observatory). [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/owj.12286)]

before taking action. These gaps depended on manipulating data they pooled through simple mathematical analysis and formulas, to provide the basis for meaningful intervention.

ROOPARSE: DATA GATHERING FOR THE LONG GAME

The third experiment was an *invoice parsing* project, developed and designed by Deliveroo riders with advanced data skills. It provides an instance of the way that some workers are seeking to empower themselves by obtaining data to enable them to monitor pay rates and their fluctuation and variations across their own city, and potentially across many cities. Whereas the initiative in Dunfermline focused on aiding an immediate intervention, and involved a significant fraction of all the UberEats drivers, who in turn were able to contact every driver in the town, riders in Edinburgh did not have specific collective demands involving a significant proportion of the workforce, nor did they have capacity to contact more than a portion of riders. At regular WO meetings in a pub in town, there was pessimism about the prospect of trying to take any snapshot of rates, or to undergo a collective process of inquiry by a group that was a tiny fraction of the total workforce. There was a broad recognition that the dearth of knowledge about basic aspects of their work meant any interventions were like shooting in the dark. However, at meetings of the group, workers decided that even if they could not simply map out the functioning of the platform, providing workers with means to know what was happening with rates and rhythms of work and pay would aid efforts to organise in the longer term, and provide individual insights that riders would find useful, relating to their pay and conditions. At this point, one of the individuals involved in the Observatory shared with the group a tool that they had designed on github, called RooParse, for parsing data from invoices to allow

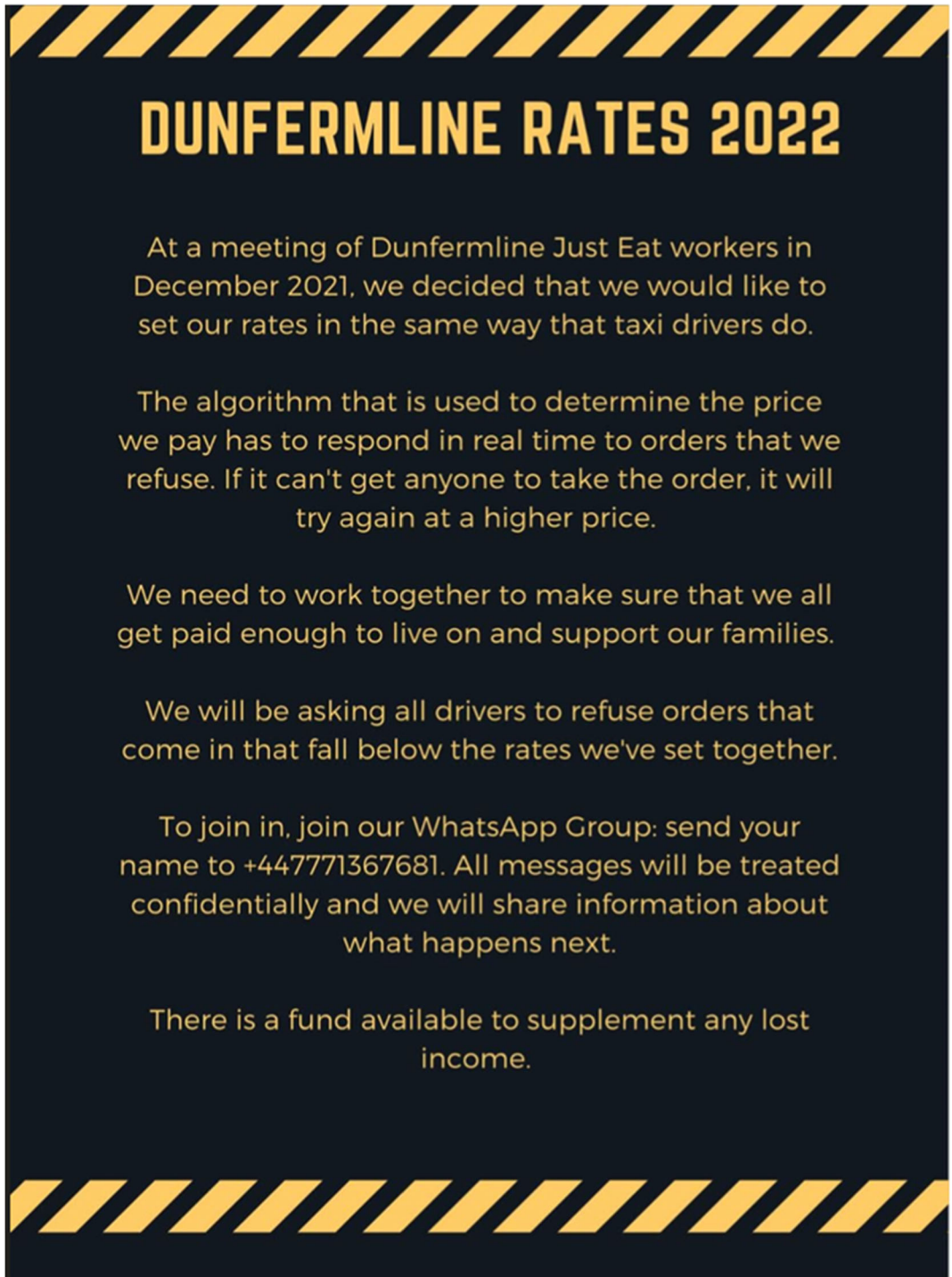


FIGURE 3 Dunfermline organising flyer (Source: Workers' Observatory). [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/irwe.12286)]

workers to chart their changing pay over time. Another member of the WO, one of the authors, then began to work on making this prototype into a functioning tool for riders to use.

The tool that was designed has the capacity to parse data from a variety of invoice types. It presents the data in ways that are meaningful to riders without skills in data interpretation. For instance, it can display the rates that people earned in weeks and in months. The tool has several main objectives. It is intended to be a free, accessible, and open-source application; and to give complete control to workers over their own data, with the ability to analyse, summarise and share results completely on their own device without handing over any personal information to third-parties, unless they explicitly choose to. It was developed with the initial goal of being compatible with payslips from multiple platforms in Edinburgh, while ensuring a software design which allows for more formats and sources to be added with relative ease to the codebase.

The development of this tool revealed multiple challenges, which are likely to be encountered in any similar attempt by workers to analyse data in platform work. Payslips and pay summaries from different companies come in a variety of different digital formats, and therefore, software with universal compatibility cannot be developed. The designer therefore settled on developing input from some common payslip formats, as well as the option to import data recorded by workers in their own spreadsheets. A bigger challenge was the availability of different types of data from different platforms: for example, some platforms provide the amount of time worked, while others provide the pay for each individual job, but not the amount of time spent. The designer therefore chose a modular approach to the development of the software, which could account for different availability of variables when aggregating and summarising data, supporting currently available data and any future data formats.

At the time of writing, the tool has been created but not yet tested by a large number of riders. The tool that was developed required expertise in data and programming, and it relied on a degree of worker-led research, with skills that amounted to those used in scientific research. To this extent, it was a worker data science project focused not on immediate ends or actions, but on equipping workers to solve problems that have the potential to be enlightening or empowering. Could such a tool generate the kinds of insights that could encourage and enable workers to scale up the kinds of initiatives that can happen in smaller localities like Dunfermline, making informed action imaginable or feasible in a city? Could it form the seeds of a database, that could enable workers across cities, or further afield, to monitor information and act upon it?

CONCLUSION: TOWARDS A PARTICIPATIVE WORKERS' DATA SCIENCE

Scholarship about work in the on-demand platform economy often tends to consider workers' experiences on the one hand, and to research the algorithmic systems on the other. While qualitative research can yield new understandings of workers' perspectives, insight into the logics and calculative processes of the platform systems they work under tend to be the result of more technical studies, often involving an application of critical data science or analysing patterns and processes of the platforms. Recently, Woodcock (2021a, p. 88) has suggested that digital worker inquiries can overcome this divide, exploring how a 'digital workerist' approach would give workers autonomy through 'combining research into digital technology and organising with inquiry'. Here, we have sought to extend that approach into the realm of

experimental tool-making and worker data science. *Digital worker inquiry* is the process, from below, of workers' collaborating to come to an understanding of their work. *Data science* is the work of using data to conduct experiments that test hypotheses, and of developing the technologies that allow researchers to do this. *Worker data science*, then, denotes the process of workers setting and testing their own hypotheses about their work, developing and using technologies to aid the process. The use of worker data science helps overcome the dichotomy between understanding workers' experiences from below and understanding the technical operations of platform systems. Where questions cannot be answered simply through inquiry, then science becomes necessary.

Where, then, does a shift from workers' inquiry to worker science become necessary. This, we have suggested, is a theoretical and historical question. The historical cases we offer point to the conclusion that in cases where there are modest modifications to technologies used in the labour process, or changes to systems of pay, then inquiry will provide workers with the insights they need to empower them to assert demands: like the GE workers, they can share experiences to inform each other about changes to the skills required to work, or like the French journeymen, they can share experiences about changes to rates of pay. But where technologies result in deeper shifts in the technologies used at work and the systems of spatiotemporal control, raw inquiry does not obtain for the workers the insights to answer their questions. Such deeper changes result in shifts in actual working patterns, and also in changes in the knowledge that workers have and can access. During such revolutions—the introduction of clock-based management that Thompson described is one, and we suggest that the use of code-based platforms is another—then worker data science can become a means of vital support and, potentially, empowerment.

We have offered three cases where inquiry was found to give rise to questions and hypotheses, which then required the development of methods or tools for answering those questions through gathering and analysing data. These three instances speak clearly to van Doorn's (2020b, p. 139) call for 'experimentation with calculative devices' as an 'alternative mode of resistance that can complement public protests, petitions or strikes'. We found that workers engage in such 'calculative experimentation' both for immediate ends, and also for longer-term interests, so that workers are engaged in developing a collective view or understanding of their own devices. While this does not restore lost tacit knowledge, this process helps to replace eroded knowledge with insight into systems of control. This kind of approach not only has the potential to provide workers with tools to support them in their work and organising methods; it also has implications for the cultures of consent, adjustment, and adaptation to new systems of control.

The past decade has seen a period of massive investment in data-driven platforms and secret software systems that control the food delivery process. While various efforts to obtain data have given workers some routes to challenging the power of these platforms, a consensus has yet to be reached as to whether retrieving or 'restoring' knowledge to workers through accessing data is an effective tool for organising, whether through GDPR data access requests or other means. However, when systems of control are concealed or opaque and workers share only tacit and informal knowledge, workers are less likely to crystallise their contentions and grievances in the form of verifiable or provable claims. On the other hand, when the built nature of platforms becomes the site and material of worker inquiry, explorative processes can provide the basis for a different relationship with platforms altogether, calling into question what Galière (2020) calls the 'normative power' of platforms. Here, platforms become a sandbox, in which workers have the right to play, or an observatory, in which they have the

tools to explore. Dubal (2023, p. 47) correctly suggests that workers ‘face a formidable task in asserting any power or control over the automated decision-making management structures’ and her calls to abolish wage discrimination, which we support, are clear. But we also suggest that in cases where workers are involved in collaborative projects, where they guide the research process, and where the development and use of tools enables workers insight into the larger technical ecology of platform power, these formidable structures may start to more look like clocks than black boxes.

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REFERENCES

- Attoh, K., Wells, K. & Cullen, D. (2019) We're building their data: labor, alienation, and idiocy in the smart city. *Environment and Planning D: Society and Space*, 37(6), 1007–1024.
- Berti Suman, A. & Pierce, R. (2018) Challenges for citizen science and the EU open science agenda under the GDPR. *European Data Protection Law Review*, 4(3), 284–295.
- Braverman, H. (1998/1974) *Labour and monopoly capital: the degradation of work in the twentieth century*. New York: Monthly Review Press.
- Burt, E. (1754) *Letters from a gentleman in the North of Scotland to his friend in London; containing the description of a capital Town in that Northern Country*. London: S. Birt.
- Calzada, I. & Almirall, E. (2020) Data ecosystems for protecting European citizens' digital rights. *Transforming Government: People, Process and Policy*, 14(2), 133–147. Available from: <https://doi.org/10.1108/TG-03-2020-0047>
- Cini, L. (2022) Resisting algorithmic control: understanding the rise and variety of platform worker mobilisations. *New Technology, Work and Employment*, 38(1), 125–144. Available from: <https://doi.org/10.1111/ntwe.12257>
- Delacroix, S. & Lawrence, N.D. (2019) Bottom-up data trusts: disturbing the ‘one size fits all’ approach to data governance. *International Data Privacy Law*, 9(4), 236–252.
- van Doorn, N. (2020a). From a wage to a wager: dynamic pricing in the gig economy. *Platforming equality*. Hampshire: Autonomy. Available from: <https://autonomy.work/wp-content/uploads/2020/09/VanDoorn.pdf>
- van Doorn, N. (2020b) At what price? Labour politics and calculative power struggles in on-demand food delivery. *Work Organisation, Labour & Globalisation*, 14(1), 136–149.
- Dourish, P. (2016) Algorithms and their others: algorithmic culture in context. *Big Data & Society*, 3(2), 1–11. Available from: <https://doi.org/10.1177/2053951716665128>
- Dubal, V. (2023) *On algorithmic wage discrimination*. (UC San Francisco Research Paper). Forthcoming. Available from: <https://ssrn.com/abstract=4331080>
- Enriquez, D. & Vertesy, J. (2021) Managing Algorithms: partial automation of middle management and its implications for gig workers. *Proceedings*. Available from: <https://doi.org/10.5465/AMBPP.2021.16560abstract>.
- Franke, M. & Pulignano, V. (2021) Connecting at the edge: cycles of commodification and labour control within food delivery platform work in Belgium. *New Technology, Work and Employment*, 38(2), 371–390. Available from: <https://doi.org/10.1111/ntwe.12218>

- Galière, S. (2020) When food-delivery platform workers consent to algorithmic management: a Foucauldian perspective. *New Technology, Work and Employment*, 35, 357–370.
- Gandini, A. (2019) Labour process theory and the gig economy. *Human Relations*, 72(6), 1039–1056.
- Gray, M. & Siddharth, S. (2019) *Ghost work: How to stop silicon valley from building a new global underclass*. Boston: Houghton Mifflin Harcourt.
- Gregory, K. (2021a) My life is more valuable than this': understanding risk among on-demand food couriers in Edinburgh'. *Work, Employment and Society*, 35(2), 316–331.
- Gregory, K. (2021b) Worker data science can teach us how to fix the gig economy. *Wired*. Available from: <https://www.wired.com/story/labor-organizing-unions-worker-algorithms/>
- Gregory, K. & Maldonado, M.P. (2020) Delivering Edinburgh: uncovering the digital geography of platform labour in the city. *Information, Communication & Society*, 23(8), 1187–1202.
- Griesbach, K., Reich, A., Elliott-Negri, L. & Milkman, R. (2019) Algorithmic control in platform food delivery work. *Socius: Sociological Research for a Dynamic World*, 5. Available from: <https://doi.org/10.1177/2378023119870041>
- Hartley, J.F. (1994) Case studies in organizational research. In: Cassell, C. & Symon, G. (Eds.) *Qualitative methods in organizational research: A practical guide*. London: Sage, pp. 209–229.
- Heiland, H. (2021) Controlling space, controlling labour? Contested space in food delivery gig work'. *New Technology, Work and Employment*, 36, 1–16. Available from: <https://doi.org/10.1111/ntwe.12183>
- Howcroft, D. & Taylor, P. (2014) Plus ça change, plus la meme chose?—researching and theorising the 'new' new technologies. *New Technology, Work and Employment*, 29, 1–8. Available from: <https://doi.org/10.1111/ntwe.12026>
- Johnston, H. & Land-Kazlauskas, C. (2019) Organizing on-demand: Representation, voice, and collective bargaining in the gig economy, Conditions of Work and Employment Series No. 94, ILO report. Available from: https://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—travail/documents/publication/wcms_624286.pdf
- Joyce, S., Neumann, D., Trappmann, V. & Umney, C. (2020) *A global struggle: worker protest in the platform economy*. Brussels: Report written for European Economic, Employment and Social Policy.
- Lata, L.N., Burdon, J. & Reddel, T. (2023) New tech, old exploitation: gig economy, algorithmic control and migrant labour. *Sociology Compass*, 17(1), e13028. Available from: <https://doi.org/10.1111/soc4.13028>
- Livingston, E. (2022) Food delivery drivers fired after 'cut-price' GPS app sent them on 'impossible' routes. *The Guardian*, July, 2. Available from: <https://www.theguardian.com/business/2022/jul/02/food-delivery-drivers-fired-after-cut-price-gps-app-sent-them-on-impossible-routes>
- MacKenzie, D. & Wajcman, J. (Eds.). (1999) *The social shaping of technology*, 2nd ed. Buckingham, UK: Open University Press.
- McCulloch, B. (2004) *Cabs, companies & characters: story of the Edinburgh taxi trade*. London, UK: New Generation Publishing.
- Mendonça, P. & Kougiannou, N.K. (2022) Disconnecting labour: the impact of intraplatform algorithmic changes on the labour process and workers' capacity to organise collectively. *New Technology, Work and Employment*, 38(1), 1–2. Available from: <https://doi.org/10.1111/ntwe.12251>
- Milan, S. (2014) The ethics of social movement research. In: Porta, D., (Ed.) *Methodological practices in social movement research*. Oxford: Oxford University Press. pp. 446–464.
- Muldoon, J. & Raekstad, P. (2022) Algorithmic domination in the gig economy. *European Journal of Political Theory*, 22(4), 587–607. Available from: <https://doi.org/10.1177/14748851221082078>
- Ness, I. (2023) *Platform labour and global logistics: a research companion*. New York, USA: Routledge.
- Noble, D.F. (1984) *Forces of production: a social history of automation*. New York, USA: Knopf.
- Popan, C. (2021) Embodied precariat and digital control in the 'gig economy': the mobile labor of food delivery workers'. *Journal of Urban Technology*. Available from: <https://doi.org/10.1080/10630732.2021.2001714>
- Richardson, L. (2020) Platforms, markets and contingent calculation: the flexible arrangement of the delivered meal. *Antipode*, 52(3), 619–636.
- Rosenblat, A. & Stark, L. (2016) Algorithmic labor and information asymmetries: a case study of uber's drivers. *International Journal of Communication*, 10(27), 3758–3784.
- Safak, C. & Farrar, J. (2019) Managed by bots: data-driven exploitation in the gig economy. Available from: <https://www.workerinfoexchange.org/wie-report-managed-by-bots>

- Shapiro, A. (2020) Dynamic exploits: calculative asymmetries in the on-demand economy. *New Technology, Work and Employment*, 35, 162–177. Available from: <https://doi.org/10.1111/ntwe.12160>
- Sharp, T. (2021) Seven ways platform workers are fighting back, TUC report. Available from: <https://www.tuc.org.uk/sites/default/files/2021-11/PlatformEssaysWithPollingData2.pdf>
- Silberman, M. & Johnston, H. (2020) Using GDPR to improve legal clarity and working conditions on digital labour platforms. Report published by the European Trade Union Institute. Available from: <https://www.etui.org/sites/default/files/2020-06/WP%202020.05%20GDPR%20Working%20conditions%20digital%20labour%20platforms%20Silberman%20Johnston%20web.pdf>
- Sonenscher, M. (1989) *Work and wages: natural law, politics and the eighteenth-century French trades*. Cambridge: Cambridge University Press.
- Stein, J. & Calacci, D. (2022) *Workers collective data access rights: adding context to worker data protection* [preprint]. Available from: <https://www.dcalacci.net/papers/202.10.10-collective-data-access-latest.pdf>
- Tassinari, A. & Maccarrone, V. (2020) Riders on the storm: workplace solidarity among gig economy couriers in Italy and the UK. *Work, Employment and Society*, 34(1), 35–54. Available from: <https://doi.org/10.1177/0950017019862954>
- Thompson, E.P. (1967) Time, work-discipline, and industrial capitalism. *Past & Present*, 38(1), 56–97. Available from: <https://doi.org/10.1093/past/38.1.56>
- Topham, E. (1780) *Letters from Edinburgh, written in the Years 1774 and 1775: Containing Some Observations on the Diversions, Customs, Manners, and Laws, of the Scotch Nation, During a Six Months Residence in Edinburgh II*. Dublin: W. Watson. pp. 216–281.
- Truant, C.M. (1994) *The rites of labor: brotherhoods of compagnonnage in old and new regimes France*. Ithaca: Cornell University Press. p. 1994.
- Vallas, S. & Schor, J.B. (2020) What do platforms do? understanding the gig economy. *Annual Review of Sociology*, 46(1), 273–294.
- Wiggins, A. & Crowston, K. (2011) From conservation to crowdsourcing: a typology of citizen science. *44th Hawaii International Conference on System Sciences*, Kauai, HI, USA, 2011, pp. 1–10.
- Wilderman, C.C. (2007) Models of community science: design lessons from the field. *Citizen Science Toolkit Conference*, Cornell Laboratory of Ornithology, Ithaca, NY.
- Wilkinson, A., Dundon, T., Mowbray, P. & Brooks, S. (Eds.). (2022) *Missing voice?* Cheltenham, UK: Edward Elgar Publishing.
- Wong, J., Henderson, T. & Ball, K. (2022) Data protection for the common good: developing a framework for a data protection-focused data commons. *Data & Policy*, 4, E3. Available from: <https://doi.org/10.1017/dap.2021.40>
- Wood, A.J., Graham, M., Lehdonvirta, V. & Hjorth, I. (2019) Good gig, bad gig: autonomy and algorithmic control in the global gig economy. *Work, Employment and Society*, 33(1), 56–75.
- Woodcock, J. (2021a) Towards a digital workerism: workers' inquiry, methods, and technologies. *Nanoethics*, 15, 87–98. Available from: <https://doi.org/10.1007/s11569-021-00384-w>
- Woodcock, J. (2021b) *The fight against platform capitalism: an inquiry into the global struggles of the gig economy*. London: University of Westminster Press.
- Wu, P.F. & Zheng, Y. (2020). Time is of the essence: spatiotemporalities of food delivery platform work in China. *Proceedings of the European Conference on Information Systems (ECIS 2020)*. Available from: https://aisel.aisnet.org/ecis2020_rp/156.

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