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Taylorism reloaded? Explaining control and resistance to algorithms in a train manufacturing company

Sander Junte
Óscar Molina
Universitat Autònoma de Barcelona, Sociological Research Centre on Everyday Life and Work (QUIT), Institute for Labour Studies (IET)
0000-0002-0085-559X; sander.junte@uab.cat
0000-0002-8660-8919; oscar.molina@uab.cat



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Abstract

The diffusion of artificial intelligence, data analytics and digital technologies in manufacturing has revived debates about the impact of technological change on work and employment relations. This article examines the implementation of Industry 4.0 technologies in a Spanish train manufacturing company and analyses their implications for workers and their representatives. Drawing on Labour Process Theory and industrial relations literature, the study is based on a qualitative case study including interviews with workers, works council members and technical staff. The findings show that the transition to Industry 4.0 primarily involved the implementation of a Manufacturing Execution System (MES), which digitalised production processes and data collection. Rather than increasing worker autonomy, the system reinforced Taylorist principles through greater standardisation, monitoring and performance measurement. The study also finds that worker representatives played a limited role in regulating technological change despite the existence of formal information and consultation rights. The article argues that technological opacity, institutional constraints and the prioritisation of traditional bargaining issues limit the capacity of worker representatives to influence the governance of workplace technologies.

Keywords: Industry 4.0; algorithmic management; Labour Process Theory; worker representation; digital Taylorism; manufacturing industry

Resumen. *¿El taylorismo renovado? Análisis del control y la resistencia frente a los algoritmos en una empresa fabricante de trenes*

La difusión de la inteligencia artificial, el análisis de datos y las tecnologías digitales en la industria manufacturera ha reabierto el debate sobre el impacto del cambio tecnológico en el trabajo y las relaciones laborales. Este artículo analiza la implantación de tecnologías vinculadas a la Industria 4.0 en una empresa española de fabricación ferroviaria y sus implicaciones para los trabajadores y sus representantes. Basado en la Labour Process Theory y la literatura sobre relaciones laborales, el estudio adopta una metodología de estudio de caso cualitativo sustentada en entrevistas con trabajadores, representantes sindicales y personal técnico. Los resultados muestran que la transición hacia la Industria 4.0 se materializó principalmente mediante la implantación de un sistema de ejecución de manufactura (MES) orientado a digitalizar procesos y recopilar datos sobre la actividad productiva. Lejos de incrementar la autonomía laboral, el sistema reforzó principios tayloristas mediante una mayor estandarización, monitorización y control del rendimiento. Asimismo, la representación de los trabajadores desempeñó un papel limitado en la regulación del cambio tecnológico. El artículo concluye que la opacidad tecnológica, las limitaciones institucionales y la prioridad otorgada a cuestiones tradicionales de negociación colectiva restringen la capacidad de intervención sindical en la gobernanza de las nuevas tecnologías.

Palabras clave: industria 4.0; gestión algorítmica; teoría del proceso de trabajo; representación de los trabajadores; taylorismo digital; industria manufacturera

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1. Introduction

Following several decades of deep winter, advances in data analysis during the 2010s has led to what has been described as a new "Summer of Artificial Intelligence (AI)" (Mitchell, 2019). Although the ambitions of scientists to develop a system capable of replicating human intelligence can be traced back to the 1960s, AI has gained renewed prominence, particularly in recent years. However, as opposed to previous "summers", it is now our society's high degree of digitalisation that has enabled data storage and collection on an unprecedented scale (Zuboff, 2019). The impact of this development has been felt in nearly every sphere of society, including the realms of work. On the one hand, the leap forward in data analysis has returned the question of what this means for automation and the disappearance of jobs to the agenda (Frey and Osborne, 2017). Beyond this debate, and more aligned with the interests of sociology of work, a body of research has also focused on the question of what the introduction of these technologies means for these remaining jobs (Doellgast and Wagner, 2022).

Perhaps the domain in which the introduction of AI has been studied the most is the platform economy, where the possibilities of "algorithmic management" has enabled companies to automate decisions such as the assignation of tasks and the calculation of salaries (Kellogg et al., 2020; Srnicek, 2016). However, research has increasingly shown that algorithms have become a new instrument within the organisation of work in other segments of the labour market as well (Baiocco et al., 2022; Wood, 2021). This also includes the manufacturing industry, although the implementation of these technologies are more frequently presented under the rubric of "Industry 4.0" (Dupuis, 2025; Krzywdzinski et al., 2025; Lloyd and Payne, 2019).

The idea behind "Industry 4.0", whose origins may be traced back to one of the world's most important industrial trade fairs – the Hannover Messe in Germany – is based on the premise that advances in data analysis have marked the beginning of the fourth industrial revolution (Kagermann et al., 2011). Because of its association with these business contexts, a widely accepted definition of what exactly Industry 4.0 entails is still missing. For instance, according to Butollo et al. (2019), its distinctiveness lies in the ubiquity of data collection and analysis technologies and the state of interconnectedness between machines, as well as between machines and workers. In addition, Pfeiffer (2017) also explicitly mentions the implementation of technologies such as robotics, 3D printing and wearables. In any case, the discourse that surrounds it – heavily promoted by governments as well as by consulting firms such as McKinsey and Company (2022) and Deloitte (2020) – has mainly emphasised the benefits of implementing Industry 4.0 for both companies and their workers, namely highly efficient production processes and jobs characterised by enrichment and greater operator autonomy.

This article aims to explore in greater depth the changes implemented within the Industry 4.0 factory. Convinced that the reality of the workplace often diverges significantly from the picture painted at the more macro / institutional level, the approach adopted in this article is more critical and focuses on plant-level dynamics. In this article, we explore the challenges that Industry 4.0 technologies pose for factory workers and their representatives. This question is broken down into two different but interrelated dimensions. The first dimension focuses on the changes experienced by operators due to the implementation of these technologies. For instance, are the changes associated with Industry 4.0 as beneficial as proponents claim, or is there more to be said about the risks posed to workers? The second dimension focuses on the role that worker representatives play in the regulation of these technologies. Does their involvement help prevent potential negative side effects, or are they instead pushed to the background because of the complexity of these technologies or their (non-existent) role in decision-making? This second dimension is particularly important considering the ongoing institutional debates about how to prepare worker representatives for the implementation of these technologies (Doellgast and Wagner, 2022; Molina et al., 2023).

To answer this question, this article presents findings from a study focused on developments within a Spanish train manufacturer that described itself as

"the first Industry 4.0 company in its sector". Conceptually, we draw inspiration from the influential Labour Process Theory (LPT), which has a long tradition of studying how technology shapes the relationship between workers and management (Hall, 2010). Building on LPT, prior research has already focused on the challenges that the Industry 4.0 factory poses for workers and their representatives. Although the findings reveal that the implementation of the Industry 4.0 factory amounted to little more than the digitalisation of operations, we will see that its most visible impact is the reinforcement of Taylorist principles in the organisation of work, leading to a reduction in operator autonomy and a perceived intensification of work on the shop floor.

In addition, research from other countries has shown that worker representatives have become involved in the introduction of new technologies in the workplace – particularly in Germany, where works councils are integrated into decision-making and the government recently expanded council members' rights with regards to AI (Bosch and Schmitz-Kießler, 2020; Doellgast et al., 2022; Pulignano et al., 2026). However, unlike cases that demonstrate how works councils have successfully protected the interests of workers during implementation, the findings of this study will show that, in our case, the Works Council explicitly refrained from addressing the impact of technology. Therefore, amid ongoing debates about how to prepare workers and their representatives for the age of AI, this article demonstrates that the technical complexity of AI systems, combined with Spain's underdeveloped regulatory framework, prevents worker representatives from recognising, and effectively responding to, the need to regulate workplace technologies. The findings show that this is the case even when it is evident that the implementation of Industry 4.0 technologies primarily benefits companies rather than workers.

2. Theoretical framework

2.1. The importance of data in the workplace

Within the field of sociology of work, Labour Process Theory (LPT) is considered one of the most influential theoretical frameworks for studying workplace dynamics (Braverman, 1998; Burawoy, 1982; R. Edwards, 1979; Friedman, 1977). Integrating a Marxist perspective, authors within LPT consider the conflict that governs employment relations inevitable within capitalist production. The source of this conflict resides in the conceptual distinction between labour and labour power. According to this distinction, labour power refers to the mental and/or physical capacities that a worker sells within the context of the employment relationship, whereas labour refers to the output produced through the deployment of this labour power in the production process. Unlike other production factors, the employment relationship is unique in that it is impossible for an employer to define an exact volume of labour to be performed at the workplace. Considering the conflict of interest, workers are assumed to strive to expend the least amount of labour power in exchange for

the highest possible wage. In contrast, employers aim to extract the maximum effort from labour power for the lowest possible wage. This conflict of interest makes a natural conversion of labour power into labour anything but self-evident (P. K. Edwards, 1986).

One of the foundational works in LPT is Braverman (1998), which attributed the emergence of managerialism at the end of the 19th century to the problems that this indeterminacy of labour power posed for employers. According to this view, Taylor's aim in introducing the stopwatch in the workshop and through Methods-Time Measurement (MTM) studies was to centralise knowledge at the level of management and ensure a sufficient extraction of labour effort at the point of production.

Although many decades have elapsed since Braverman opened the debate, the framework continues to be highly appropriate for studying workplace dynamics. In particular, authors have focused on the role that technology plays as an important variable within the conversion of labour power (Hall, 2010). This is also the reason why LPT has been explicitly cited as one of the most prominent frameworks for studying the risks that the introduction of Industry 4.0 technologies carry for workers (and their representatives) (Zhang et al., 2025). Building further upon the premise that employment relations are marked by a conflict of interest, scholars have emphasised how these technologies further enable management to retrieve real-time data about what happens on the shop floor (Krzywdzinski et al., 2025). Considering these new opportunities for measuring and monitoring, the introduction of these technologies has prompted numerous scholars to conceptualise this organisation of work as a type of "digital Taylorism", which may be described as "a variety of forms and combination of soft- and hardware [that] as a whole allow for new modes of standardization, decomposition, quantification, and surveillance of labour – often through forms of (semi)automated management, cooperation and control" (Altenried, 2022).

It is true that most of this research has explicitly focused on the concept of "algorithmic management", the emergence of which may be directly linked to the platform economy (Duggan et al., 2020; Kellogg et al., 2020). Because much work in this segment of the labour market is carried out by (bogus) self-employed workers, some of the insights from this research may not be directly generalisable to workplaces where a traditional employment relationship prevails. While acknowledging this caveat, this article follows other studies in considering these insights highly relevant for workers within the digital Industry 4.0 factory (Dupuis, 2025; Krzywdzinski et al., 2025). It is to these insights that we now turn.

2.2. The risks of the digitalised workplace

Our previous examination of LPT showed that it is one of the most widely cited frameworks for highlighting the challenges associated with the introduction of AI on the shop floor. Based on this research, this section will outline challenges that scholars have identified.

Firstly, one of the most mentioned challenges is the reduction of operator autonomy (Butollo et al., 2019; Dupuis, 2025). Although autonomy of work is widely regarded as one of the most important dimensions of job quality, the principle clashes with the standardisation of the labour process imposed by Taylorism (Wheatley, 2017). Previous research, such as those of the call centre debates at the turn of the century or the recent platform debate, has already demonstrated how the digitalisation of workspaces has operated as an important instrument for restricting workers' autonomy (Bain and Taylor, 2000; Rosenblat and Stark, 2016).

Similarly, within the manufacturing industry, this digitalisation has become a reality through the introduction of Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES) (Butollo et al., 2019). The aim of these systems has mainly been to digitalise all operations and provide managers with data on the production and productivity of the factory (Schaupp, 2023). Consequently, one of the benefits of these systems is to help management optimise production and thereby implement a "lean production" system (Butollo et al, 2019). However, as initial research from Butollo et al (2019) has shown, the introduction of these systems has also afforded management the possibility to control the work of operators in real time.

This risk is further exacerbated by the introduction of wearables on the shop floor, which can be considered another innovation promoted as part of the Industry 4.0 discourse (Pfeiffer, 2017). On the one hand, enabling the timely detection of improper working postures or fatigue devices such as data glasses or smartwatches can potentially improve operator ergonomics during assembly. However, the other side of the coin is that these wearables may further restrict operators' autonomy by tracking their location within the factory, monitoring the speed of task completion or, in the most extreme cases, even collecting biometric data such as heart rate (Evers et al., 2018).

Krzywdzinski et al (2025) show that in capital-intensive industries such as manufacturing, risks are less related to standardisation and more to an increased intensification of work. This may therefore be considered a second major challenge associated with the introduction of data analysis-related technologies (Baiocco et al., 2022). The automation of instructions or the pace setting of machines can lead to an increase in productivity, but places further pressure on workers to meet the pace dictated by the system. Also, considering the ubiquity of these data collection systems, in the event a worker deviates from the instructions provided by a system, this information can be instantaneously captured and sent to the responsible manager (Todolí-Signes, 2019).

In the third case, literature has pointed to the opaque nature of these technologies. Because of this opacity, the implications of these systems for working conditions are very difficult or even impossible to interpret by non-experts (Jarrahi et al., 2021). Within the literature, this difficulty has been conceptualised as the "black box" problem: although the manager might be aware of the system's input and output, the algorithms' route between those phases are difficult to trace (Ajunwa, 2020; Pasquale, 2015). In cases where important

decisions are delegated to algorithms, the opacity of these systems can lead to a problem of accountability in the workplace. As Aloisi (2024) argues, it is not as if flesh-and-bone managers were always free from fault, but at least it was possible to hold them accountable for their decisions. In the case of data analysis systems, this principle of accountability is hard to apply. Moreover, due to the ubiquity of these systems, the implementation of such technologies risks further exacerbating information asymmetries between workers and management in favour of the latter (Rosenblat & Stark, 2016).

While our examination of these challenges may seem mainly theoretical, a body of research has demonstrated the extent to which they risk becoming a reality. For instance, drawing on the *EU-OSHA European Survey of Enterprises on New and Emerging Risks*, Brancati and Curtarelli (2021) have shown how "the presence of technologies monitoring worker performance and determining the content or pace of work in an establishment, all potentially used to enable algorithmic management of workers, are associated with an increase in reported psychosocial risks in the workplace" (p. 23). Similarly, a study by Payá and Pizzi (2024)así como los daños a la salud asociados en el medio laboral europeo.\nMétodo: Estudio transversal con los microdatos de la encuesta de 2022 "Occupational Safety and Health in Post-Pandemic Workplaces (Flash Eurobarometer based on the *Occupational Safety and Health in Post-Pandemic Workplaces* has shown that, in cases in which AI assumes the role of "digital supervisor", work tends to become less autonomous and more intensive. According to their analysis, this further leads to the individualisation of work and the erosion of cooperation between workers. In light of these insights, it is not without reason that a debate has emerged in recent years about the role that unions and worker representatives play within the implementation of these technologies. The following section will explore this issue further.

2.3. Regulating the algorithm: contributions from employment relations

In addition to the challenges that Industry 4.0 poses to operators, the second dimension focuses on the role that worker representatives play in the integration of these technologies. The importance of this dimension is not minor. Although LPT has traditionally focused on the privileged role of employers in the organisation of work, this denies the collective agency of workers in shaping the implementation of technology (Hall, 2010). Complementary to this premise, contributions from the field of comparative employment relations have revealed cases in which the role of worker representatives has been decisive in mitigating the negative impact of these technologies on workers or helping to reduce risks at work (Doellgast and Wagner, 2022; Molina et al. 2023).

In recent years, a debate has emerged both among scholars and policymakers about the instruments required to prepare worker representatives for the age of AI (Krzywdzinski et al., 2023). For instance, based on developments within several European countries, Molina et al (2023) distinguish between three phases that should ideally involve workers or their representatives: data

collection, algorithm design and the use of AI in the organisation of work. However, this framework represents a best case scenario, i.e. a normative model still far removed from the realities of the workplace. For worker representatives to become involved in the regulation of technology, previous research has highlighted two necessary preconditions.

Firstly, Rego (2022) emphasised the importance of worker representatives perceiving the introduction of technology as a process in which they can intervene and one in which it is worth intervening. This awareness, however, is far from self-evident. Technology continues to be an issue that is not necessarily considered an area of expertise of trade unions, and the impact on working conditions is difficult to forecast (Edwards and Ramirez, 2016). In the case of AI, this is further compounded by the aforementioned opacity or "black box" nature of these systems, which makes it difficult for union representatives to understand the operations, let alone assess their impact (Jarrahi et al., 2021). Thus, trade unions may be more inclined to address concerns related to wages and working conditions.

For this reason, governments and/or union confederations across Europe have adapted existing institutions or created new ones aimed at strengthening the role of worker representatives. According to prior research, the strength of their resources in the workplace is considered a second important condition for successfully protecting workers from the negative impact of technology (Bosch and Schmitz-Kießler, 2020; Dupuis, 2025). On the one hand, scholars have pointed to collective bargaining as the most appropriate instrument for "negotiating the algorithm" (De Stefano and Taes, 2023; Todolí-Signes, 2019). Unlike changes within legislation, the flexibility of collective bargaining provides unions sufficient room to adapt regulation to sectoral or company-specific challenges. Moreover, the institutionalised and repetitive nature of these negotiations allows unions to carry forward any suggestions from the previous collective agreement into the next collective bargaining round. On the other hand, research has shown that access to institutional or structural resources, such as a highly qualified workforce or the scarcity of qualified workers in the labour market, has allowed works councils to contest the introduction of these technologies (Doellgast and Wagner, 2022; Dupuis, 2025; Pulignano et al., 2026).

It should come as no surprise that most of the research that has successfully identified cases of works councils regulating technology comes from Germany (Bosch and Schmitz-Kießler, 2020; Doellgast et al., 2022; Evers et al., 2018). Not only does Germany's comprehensive system of co-determination integrate works councils into managerial decision-making and the introduction of technology, but in 2021, the government also further expanded councils' rights in relation to AI. Particularly in view of the difficulties that council members have in understanding the impact of AI, councils are able to hire experts to assess the impact of systems on working conditions, with all expenses borne by the company (Hassel and Özkiziltan, 2023)

In the case of Spain, the government has also taken significant steps to prepare workers and their representatives for the age of AI. For instance, the Spanish Data Protection Regulation explicitly limits the extent of manageri-

al control by emphasising the right of workers to privacy in the workplace, particularly with regards to video and audio recordings and the use of GPS at work (Lara, 2022). In the field of collective rights, the publication of Royal Decree 9/2021 has expanded the rights of works councils to be informed about the use of algorithms in the workplace. According to the reformed Workers' Statute, article 64.4(d) now "requires employers to provide workers' collective representatives with relevant information on the use of algorithms or artificial intelligence systems in decisions that may affect working conditions, access to employment or job retention, including profiling."

However, despite the priority that the Spanish government has placed upon regulating AI in the workplace, it should be noted that these changes are being introduced within an industrial relations framework that lacks the institutional complementarities found in other Western European countries (Köhler, 2018; Prieto, 2024). Confronted with an economy that is more exposed to fluctuations than its European counterparts and relatively high rates of unemployment, the possibilities of Spanish unions – primarily, CCOO and UGT – to put employers under pressure is more limited. As a legacy from the past, the government remains highly involved in the regulation of working conditions, resulting in high collective agreement coverage but often limited depth (Hamann, 2012). Consequently, only a handful of collective agreements have begun to address AI, and most of them merely reproduce rights already established in statutory law (Bastante and Rodríguez, 2025). Regarding the role of worker representatives, although they formally have the right to be informed about the introduction of AI, they remain fully dependent on the willingness of companies to provide information. This means that, as opposed to the abovementioned case of German works councils, Spanish works councils lack access to the specialised know-how necessary to understand the impact of these systems. This raises further questions about the extent to which workers' representatives can effectively assert their rights vis-à-vis employers. As we will see, this issue will become clear in the findings.

3. Methodology

This article draws on a case study from a train, tram and metro vehicle manufacturer located in the metropolitan area of one of the largest cities in Spain. The case study is considered appropriate within the field of sociology of work, because it allows for the analysis of a phenomenon in its context (Yin, 2018). In particular, in the field of employment relations, the case study is considered an important methodology for understanding the challenges faced by unions (Kitay and Callus, 1998). The case was selected on the basis of two criteria. Firstly, in 2016, the factory under study declared itself the first "Factory 4.0" in the sector, suggesting that at least some changes had taken place within the plant. Secondly, the factory is known for having high levels of union membership, which (at least theoretically) ensures the capacity of unions to influence the introduction of new technologies in the production process. After prese-

lection, the appropriateness of the case was discussed with unions at sectoral level, who confirmed that the factory had recently undergone a significant technological upgrade.

Fieldwork consisted of thirteen interviews with workers and union members, of whom ten were directly employed in the factory. Three of the interviewed representatives are considered decision-makers within the council, which is why we consider them "high-profile unionists". The interviews included questions related to the organisation of work within the factory, the system of worker representation, relations with management, priorities of workers representatives and the impact of technology on the organisation of work, potential positive and negative effects and the extent to which it was involved in the implementation of technology. The remaining interviews were conducted with three workers' representatives who also worked in the factory and seven workers (all members of the union). The interviews focused primarily on changes within the factory and how the workers experienced the introduction of technology. An interview was also carried out with an industrial engineer. This interview focused exclusively on the role of data in factory operations. Unfortunately, it was not possible to interview the company's management, despite several attempts.

The relation with the theoretical framework as constructed in Section 2 followed an abductive logic, meaning that the outcomes of the fieldwork were continuously contrasted with multiple theories in the field of sociology of work (Timmermans and Tavory, 2018). Because the introduction of technologies led to a revival of Taylorism in the factory (see findings and discussion), the insights from the LPT framework were considered appropriate for explaining the implementation of digital technologies. Likewise, as the interviews progressed, the risks identified by works council members aligned with those documented in research on algorithmic management in platform work, making the extrapolation of these insights suitable for framing the risks associated with the "Factory 4.0".

The interviews were carried out between January and September 2023. All interviews were recorded and transcribed with the interviewees' permission. The transcripts were uploaded to AtlasTi and organised thematically with the help of coding. The codes were defined based on the concepts of the challenges identified in Section 2.2 (autonomy, monitoring, opacity) and the specific features of the case (Methods and Times department, bonus system, "pact of no collaboration", etc.). Within the context of a national knowledge seminar organised to discuss the project's results, the research outcomes were presented and discussed in a roundtable format with representatives from the employers' association and union, all of whom were familiar with developments in the factory, further strengthening the validity of the findings.

4. Findings

The following sections present the findings of our case study. In Section 4.1, we outline the background of the company and what the transformation into

an Industry 4.0 factory entailed. In Section 4.2, we focus on the limited role of the Works Council during the implementation process and the challenges posed by the system's opacity. Although we will see that implementation rebalanced the power relationship in favour of the company, section 4.3 will show how the Council kept the introduction of the MES from deteriorating the workforce's working conditions. In contrast, we will see that other issues, such as reduced autonomy and the perceived intensification of work, are acknowledged but not considered a priority.

4.1. Precedents and the train manufacturer's roadmap to the paperless factory

The factory under study operates under the umbrella of one of the world's largest multinational train manufacturers and is based in the metropolitan area of one of Spain's largest cities. Within the factory, the approximately 700 operators are represented by a works council composed of 30 members from the two major Spanish unions: CCOO and UGT. In the region, the factory is regarded as a stronghold of unionism, with roots that can be traced back to the Francoist period. This legacy has also contributed to a high level of union density: together, the two unions represent approximately 90% of the workforce. The factory's workers are covered by their own company-specific collective agreement.

In addition to the Spanish factory, the multinational operates in multiple countries in Europe and across the world. Interviewees have emphasised that the factory is exposed to infra-firm competition, in which plant productivity is constantly benchmarked and used by headquarters to assign production and investment. As in other sectors within the manufacturing industry, the Works Council has occasionally faced the threat of whipsawing, i.e. the threat that if management accepts union demands, headquarters will relocate production away from the Spanish site (Aranea et al., 2021; Greer and Hauptmeier, 2016).

The multinational's main clientele consists of public railway operators that launch their projects through competitive tenders on which the company bids. In these bids, headquarters and the client define the technical specifications and the timeframe within which the vehicles must be completed. Although headquarters has made attempts to standardise the vehicle platforms on which trains and derivatives are accommodated, each project must still be individually adapted to the client's specific requirements, such as passenger capacity or platform height in the respective country. Within the factory, this responsibility lies with the Industrialisation Department, which is responsible for organising production. The department includes a Methods and Times section that plays a central role in human resource management. Based on time measurements and direct observations on the shop floor, this section develops instruction cards for operations and defines the "standard time" in which operators are expected to complete each task. The procedures by which engineers conduct the MTM studies are regulated under the company's collective agreement.

Because of the heterogeneous nature of the clientele (railway operators from all over the world) and the number of projects, production takes place in small

batches. As a result, the introduction of an assembly line or multi-purpose machines has not been considered profitable. Instead, work in the factory is organised on a workshop basis, in which the vehicle is transported through the different departments (welding, fitting, painting, etc.), and the operators rotate around the vehicle to carry out their respective tasks. To encourage compliance with standard times, worker wages are comprised of a fixed and variable component. The variable component depends on the extent to which operators are able to finish the operation, the "method time", within the standard time. The factory is labour-intensive, which makes compliance with standard times essential, both for ensuring profitability and for finishing vehicles within the agreed timeframe.

> That is to say that, if the method time is equal to the standard time, we have a productivity of 100%. Of course, because the operator has managed, in one way or another, to do the task assigned to them within the time they were given, right? They've been very efficient – very optimal. Conversely, if that time is exceeded, then we're already talking about productivity slightly below 90 or 80 percent. And… what's interesting is that the operator can perform the work as close as possible to the standard time, right? (Industrial engineer)

One of the most recent changes in the organisation of work at the factory was its shift towards Industry 4.0. The introduction of Industry 4.0 technologies occurred after years of conflicts during the economic crisis of 2008. Confronted with a decline in orders, management carried out four rounds of collective redundancies, which together resulted in the dismissal of more than 250 workers. Each round was heavily contested by the Works Council with strikes and demonstrations, making this period extremely difficult in terms of social partnership. After a change in factory management, a new investment cycle began in 2016, during which management announced the implementation of Industry 4.0 technologies.

According to management's announcements in the press in 2016, this included all familiar Industry 4.0 technologies such as data analytics, additive manufacturing, the Industrial Internet of Things, autonomous robots, sensor-equipped suits and cloud storage. The situation observed in 2023 is notably different. A recently awarded macro-project had secured the factory's future in the medium term, fostering a more collaborative relationship between management and the Works Council. However, when asked about the changes of the "Industry 4.0 factory", the feeling transmitted by Works Council representatives is that nothing disruptive had taken place within the factory. In fact, the use of robots has been limited to the recently assigned macro-project (which did not lead to any job losses), while experiments with sensor-equipped suits appear to have been nothing more than a stunt to gain attention from the press.

Most of the changes in the Industry 4.0 factory are the result of the introduction of a Manufacturing Execution System (MES). This system was developed and implemented by an external supplier and, by the time it was introdu-

ced at the Spanish plant, was already in use at other sites of the multinational. One of the main differences brought about by the introduction of the MES was the digitalisation of all factory operations. This includes the data collected through operators' logins. This information is not accessible to operators nor their representatives, but is available to factory management and, most importantly, the multinational's headquarters:

> Because we are not just an isolated site. Not an isolated factory. There are multiple sites, so to speak. This way, headquarters can monitor and control all the data in real time, right? Production data, quality incidents, hours worked, materials used. In other words, everything, very general, worldwide. (Industrial engineer)

Although these changes may initially seem minimal and, according to the council members themselves, the introduction was not considered a risk for the union, the following section will show that its implementation has not been without consequences.

4.2. Challenges for the union

Firstly, it must be mentioned that the Works Council never shied away from embracing technology as a means of improving the plant's competitiveness. Consequently, the attitude of the Works Council towards the implementation of technology has remained neutral, and occasionally even favourable:

> In the organisation of work, we always consider this the responsibility of the employer. I mean, this isn't Germany's co-management system. So, the employer's only role is to inform you: "I'm going to do this." And that's it. What we do is ask, "Hey, does this affect us in any way? Yes or no? Does it impact…? Does it impact our pay? Does it impact our salary? Does it impact the work pace? No? Then inform me, do whatever you want, and that's it. If it affects us in any way, we'll see. But as a general rule, it doesn't affect us at all." (High-profile works council member 1)

This is also reflected in the collective agreement, where the involvement of the Works Council in technology is absent. As a result, during the implementation of the MES, the Works Council was not necessarily against the imposed changes. The implementation of this technology was considered another strategy to improve the factory's competitiveness, with no further questioning or exploration as to the role that data collection and analysis would play. However, what the Works Council did notice is that, in recent years, management has started to use data more aggressively to emphasise the high operational costs of the Spanish factory compared to other sites. For example, in a recent incident, management warned that the Polish plant was catching up in terms of both production costs and speed, prompting some of the council members to visit the site and assess the situation.

> They were doing it faster. The same type of train, and one of the bosses was suggesting taking it from here and bringing it to Poland. But there they didn't have anything to measure. The only thing they said was, "Hey, if in Poland, to make this train, it takes this much time globally, here it will take the same," without looking… So, we sat down with them and said, "Hey, are you really comparing properly? Are you comparing apples to apples? Are the procedures the same? Or aren't they?" "Yes, yes." I said, "Yes? No problem, we're all going to Poland." (High-profile works council member 2)

Ultimately, the visit to the Polish site led to the conclusion that the situation was too distinct from the Spanish site to be comparable, with the conflict ultimately blowing over without any real consequences. Nevertheless, this data-driven assault on the Works Council has also extended to collective bargaining with management. Although the previous example has already demonstrated the limitations of direct comparisons between sites, management continues to block proposals from the Works Council by comparing data from the Spanish plant with others:

> I don't know how they come up with it, but whatever we ask for is being compared to the "hourly rate". What we try to make clear is that: "we don't measure with the same numbers as you". Yes, we also measure in time, but time we want to spend with our family, to rest and to work less. However, they measure everything against this hourly rate, and I sincerely don't know how they come up with it. (High-profile works council member 3)

As we have seen in Section 2, the expansion of information and consultation rights has entitled works councils to be informed about the use of algorithms in the workplace. However, despite concerns that the use of this data undermines collective bargaining strategies, council members continue to downplay the role that the MES plays in data collection. This perceived system opacity is also reflected in the quote below, which simultaneously underlines an awareness of the use of technology while at the same time overlooking or downplaying its importance:

> We have nothing from 4.0. I always say it. That's why… [Reflects] Obviously, behind the MES there will be, obviously, artificial intelligence. Obviously. I mean, this is clearer than water, and they'll measure it with some averages. Or something like that. But… we're very unsophisticated. (High-profile works council member 1)

It is for this reason that the Works Council has not considered opening the "black box" a medium-term priority. Even with the extension of their information and consultation rights over the use of algorithms, this issue remains low on their agenda: whereas the responses from management will not provide them with sufficient information, the Works Council does not consider invoking this article worth the effort. Instead, it aims to foster collaborative relationships to co-manage the expansion of the factory. However, following

management's attempt to introduce an individualised bonus system, the Works Council did undertake further action, as discussed in the next section.

4.3. Work reorganisation: the introduction of the Manufacturing Execution System

The most direct and visible implication of the introduction of the MES was experienced by operators on the shop floor. Prior to the introduction of the MES, operators were required to record their "method times" with pen and paper, which were then passed on to the human resources department to calculate bonuses. One of the aims of the MES was to digitalise all these processes. As a result, upon arriving at the factory, operators are now expected to consult operations assigned by the MES on a tablet, clock in when they start and clock out when they finish. The status of the operations can be viewed by shop floor managers both in real time and retrospectively, and the data are stored to automate the calculation of the variable component of the wage. As part of the MES, management announced that all operations would be subdivided into micro-operations. As a result, the intervals between clocking in and clocking out became substantially shorter.

> Because before… well, you were working on the whole wagon, and there was nothing that forced you to clock those hours. You just did five different things, and at the end of the day, you would say: "In these two hours I did this, I did that." Basically, you justified yourself. No more. Now we have different tasks, and there are tasks that take two hours but also tasks that take five minutes. (High profile works council member 2)

For operators on the shop floor, the introduction of this system led to a significant reduction in autonomy and a (perceived) intensification of work. As mentioned by an interviewee who combines her duties as council member with work as a plant electrician, the role that Methods and Times play is a frequent subject of conversation among workers:

> O: Older people, yes, they… complain a lot about the times. And people who have… I'm talking about, well, I don't know, like… I'm an electrician, right? So, for example, a plumber – they have an incredible number of hours, and you sometimes really have to adjust to what they give you, right? Of course you complain. I haven't complained. Not yet. But yes, I've seen it in colleagues. So, well, I suppose that Methods and Times will come to check you out.
>
> I: Is this a recurring topic among you, these times, I mean? Do you talk about it?
>
> M: Yes, of course we talk about it. Keep in mind, though, it's a stress you carry every day. You work under times. You have to get it done. Like I said, you have a new project, you are starting to get it under control, and then you see… no, you can't make it. Well, something will happen, right? They come to time me and see… (Works council member and factory operator)

Moreover, after the introduction of the MES, the gap between the "standard times" assigned to micro-operations and the "method times" seemed to widen significantly, and it was unclear for the Works Council where these differences were coming from.

> There was quite a substantial change with regards to the timing and the working methods. Because those of us who have been here for many years are very aware how long it takes to finish certain operations. For instance, completing the wiring from top to bottom used to take twenty-four hours. Now you go, and the wiring from top to bottom takes twelve hours, right? So, why is that? Because there's no method behind it that supports the time or the process or anything. The only thing they've done is that, if in France it takes fifteen, then here it has to be done in twelve. (High-profile works council member 2)

These differences in methods and standard times and the inability to hold anyone accountable clashed with the second measure that management sought to implement, namely the reversal from a collective to an individual bonus system. This means that, instead of receiving a bonus when the operators finished the macro-operation as a team, bonus payments would be dependent on the extent to which the individual operators met the standard times. This measure was heavily criticised by the Works Council. Firstly, because, according to the Works Council, the implementation of an individual system is incompatible with the workshop-based organisation of work in the factory. Secondly, the Works Council feared that this would further undermine cooperation between operators. As management initially refused to reconsider the proposal, the Works Council responded through what is referred to as "the pact of no collaboration". Under this, the Works Council announced that, for an indefinite period, operators would strictly adhere to the instructions provided by the Methods and Times department. According to the Works Council, this would have made it is impossible to finish the vehicles:

> What we were saying is, "if we follow the instruction cards as they are written right now, I am going to do precisely what the instruction card told me to, with the material it tells me to and the time it gives me to." With the end result that the vehicle will never be finished. They'll ask: "hey, why didn't you assemble this part of the vehicle?" So, I'll say: "well, it doesn't appear in the instruction card…" (High-profile works council member 3)

Consequently, to avoid disruption to production at the factory, management ultimately capitulated and agreed with the Works Council that all operators would receive 115% of the individual bonus, regardless of whether they met the standard time. This means that, for the moment, the Works Council effectively achieved a wage increase. Management and the Works Council agreed to postpone the new bonus system for future collective bargaining rounds, although the issue was not settled in the 2024 collective agreement. However, this does not detract from the fact that operators continue to clock

Table 1. Impact of the MES on the train manufacturer

Reduction of autonomy	Operations have been divided in micro-operations, and the need for operators to clock in and out for each micro-operation has significantly reduced the autonomy of operators to organise their own shift. The digitalisation of operations has increased the possibilities for managers to consult their operators' activities both in real time and retrospectively.
Intensification of work	The division of tasks into micro-operations has led to a "perceived" intensification of work. However, because of the 115% agreement, the Works Council has prevented working conditions from deteriorating.
Opacity	The MES is opaque in a twofold sense: workers are not informed about the ultimate use of the data, and the Works Council is confronted with data collected from an unknown source. Despite the awareness that the MES processes data about operators, the Council does not consider opening the "black box" a priority.

Source: Compiled by authors.

in and out through the tablet, enabling management to continue to collect and store data for purposes not directly clear to the Works Council. These findings prompt us to conclude that, although the workers' wages have been protected (in the medium term), the Industry 4.0 factory has exacerbated the challenges mentioned above. This is summarised in Table 1.

5. Discussion

The question this article aims to answer is to what extent Industry 4.0 brings new challenges for plant operators and their representatives. In the introduction, we mentioned that the Industry 4.0 discourse presented itself with force in business contexts such as trade fairs and congresses, accompanied by promises of new opportunities for companies and their workers – particularly as digitalisation, interconnectedness and wearable technologies were expected to enable more efficient production that maximises the potential of operators (Deloitte, 2020; McKinsey and Company, 2022). Our findings on the implementation of these technologies in a train manufacturing factory, however, have shown that the transformation towards an Industry 4.0 factory has failed to live up to the expectations this discourse conveys.

First and foremost, it is important to emphasise that, ever since the opening of the factory, the small batch production and impossibility to operatively introduce an assembly line forced management to organise work on a workshop basis. In this context, the key for coping with the indeterminacy of labour power has been to divide wages into a fixed and variable component, with payment of the latter dependent on the extent to which operators were able to meet the standard times defined by the Methods and Times section. This means that organisation has always been highly implemented according to Taylorist principles. Although management explicitly announced that the plant would be the "first Industry 4.0 factory in its sector", the reality is that

the digitalisation of operations through a Manufacturing Execution System (MES) merely reinforced the Taylorist organisation of work.

Although the changes in the organisation of work have been far more incremental than the Industry 4.0 discourse suggests, the findings have also shown that this reinforcement of "digital Taylorism" is not without consequences for operators and their representatives. Building on the premises of LPT, we have seen that researchers have argued that the introduction of data collection and analysis technologies provides management new opportunities to centralise knowledge while simultaneously strengthening control over the extraction of labour effort at the point of production (Evers et al, 2018). Based on our literature review, we identified three challenges for workers and their representatives, namely the reduction of autonomy, the intensification of work and the opacity of the system, which reinforces information asymmetries.

The findings confirm that, despite amounting to little more than the digitalisation of time management, the transformation exacerbated all three of these challenges. Therefore, from an LPT perspective, we can conclude that the introduction of the MES ensures that labour power is converted into labour. This is particularly leveraged through the imposed requirement to clock in and out for every micro-operation, which provides management with information about each operator's individual performance. Contrary to the opportunities that Industry 4.0 supposedly offers to both companies and workers, this case has shown how the implementation of the MES has enabled a "control of performance of every labour activity, from the simplest to the most complicated" (Braverman, 1998: 62).

At the same time, the theoretical framework has also emphasised the role that unions and worker representatives can play in the implementation of these systems. Prior research identified two conditions that enable works councils to successfully protect workers from deteriorating working conditions: firstly, the extent to which council members perceive the regulation of technology as possible; and, secondly, the institutional and structural resources for works council to intervene (Dupuis, 2025; Pulignano et al., 2026). Despite Spain's relatively fragile industrial relations framework, our findings show that the role of works councils within the factory is far from insignificant. In fact, the "pact of no collaboration", which ensured that operators received 115% of the variable bonus regardless of whether they met the standard times, demonstrates that the council plays a strong role in bread-and-butter issues and is not afraid to mobilise its structural resources to assert its power at the bargaining table.

However, despite being at the forefront when it comes to protecting wages, other challenges such as the reduction of autonomy and the perceived intensification of work are acknowledged but not considered a priority by the Works Council. The cited reason for this is that, because of their explicit consideration as managerial prerogatives, these issues were not perceived as areas for intervention. The same goes for the more indirect implications of the MES, such as questions about data collection processes. The Works Council's position on

this issue can be considered remarkable, especially given that the same council members experienced unexplainable changes in standard times and the data-driven undermining of their collective bargaining strategies. However, in light of the downsizing the factory underwent during the aftermath of the crisis and the difficult relationship with management in subsequent years, the current priority is to foster collaborative relationships and capitalise on the opportunities created by the assignation of a macro-project.

These findings reveal two observations relevant to the debate on how to prepare worker representatives for the age of AI (Molina et al. 2023). First, in relation to the challenge of opacity and the debate about providing worker representatives with instruments to open the "black box", this case shows a divergence between the importance scholars and policymakers attribute to this issue and that attributed by the beneficiaries themselves (i.e. the Works Council). In the Spanish case, we have seen that this resulted in the expansion of works council information and consultation rights (Molina et al., 2023). However, our findings at the micro-level of the plant show that this relevance, although not entirely absent, is in any case not a priority.

In addition, if policymakers genuinely aim to strengthen the role of works councils, the findings suggest that the current regulatory framework fails to meet the objectives. More specifically, if we compare the government's advances with developments in other countries such as Germany, the mere formulation of rights in terms of information and consultation continues to render Spanish works councils dependent on the willingness of the company. In view of this unequal power balance, perhaps more pronounced in Spain than in other Western European countries, the government's efforts to prevent the introduction of algorithms from further weakening the position of workers and their representatives risk remaining a dead letter.

Ultimately, with the aim of contributing to debates about Industry 4.0 and the role of worker representatives, this article has focused almost exclusively on challenges related to technology. However, although we deliberately refrained from addressing other questions, the findings also draw attention to the limited scope for Spanish works councils to become involved in matters that appear to be equally (if not more) important. These include the unilateral imposition of work organisation and the ways in which the threat of losing investments and production to other sites undermines collective bargaining strategies. In future research, this decentring of technology should be taken into consideration in debates on improving the lives of plant operators.

6. Conclusion

This article has focused on the changes brought by the industry 4.0 paradigm for workers and their representatives. Although mostly associated with business contexts, the Industry 4.0 paradigm has been increasingly introduced as the framework under which scholars have studied the introduction of data collection and analysis and other hyped innovations ranging from robotics

to wearables (Pfeiffer, 2017; Pulignano et al., 2026). Our case study of a train manufacturer's transformation into an Industry 4.0 factory shows that, contrary to the discourse surrounding it, this process largely resulted in the digitalisation of time-management processes. However, far from without consequences, the implementation of a Manufacturing Execution System (MES) has led to a reinforcement of "digital Taylorism", in which operators are required to constantly clock in and out according to the timeframes within which they finish their operations. In this case, the relatively highly skilled workforce has leveraged the Works Council to prevent management from introducing an individual bonus system, thus preventing the individualisation of labour relations. Yet beyond the protection of workers' wages, management has refrained from prioritising the regulation of technology and has instead focused on the expansion the factory is expected to undergo in the coming years.

Because of the relatively strong role of the Works Council at the factory, this case can be considered an interesting laboratory for studying the extent to which council members in Spain can regulate technology. However, this does not mean that our research and its contributions are without limitations. First, the findings are based exclusively on views from interviewees affiliated with one of the major unions. Despite several attempts, management refused to participate in the project, leaving questions about the reasons for their refusal and their views on the developments unanswered. Second, it is important to re-emphasise that, in this case, the Works Council has been leveraged by a relatively skilled workforce, and that this resource has enabled the Council to prevent management from introducing an individual bonus system. In sectors of the manufacturing industry where work is less skilled, the outcome may be different. Third, this research was carried out while the factory was undergoing an expansion phase. The broader economic context is an important variable in shaping relations between management and works councils and therefore influences the union attitude towards the introduction of technology (Howcroft & Taylor, 2023). In this case, the shift from challenging years to a relatively positive context facilitated the introduction of technology, even though the Works Council acknowledged the drawbacks of other measures. Therefore, it would be valuable to examine to what extent changes in the economic situation might lead to a reordering of works council priorities, potentially elevating the issue of technology on the agenda.

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