

# From Taylorism to Digital Taylorism: Reframing Labour Control through the Theory of Optimum Labour Autonomy

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## Abstract

The evolution of industrial production has consistently been shaped by the tension between organizational efficiency and labour autonomy. While Taylor's Scientific Management institutionalized labour control through standardized work methods and time-and-motion studies, the emergence of Industry 4.0 has transformed these principles into algorithmic management supported by artificial intelligence, cyber-physical systems, and real-time digital surveillance. This paper critically examines the historical continuity between Taylorism and digital Taylorism and investigates how technological advancement has reconfigured, rather than replaced, mechanisms of managerial control. Using an integrative theoretical approach, the study synthesizes insights from Taylorism, Labour Process Theory, Foucauldian surveillance, algorithmic management, Human Relations Theory, Socio-Technical Systems Theory, Self-Determination Theory, the Capability Approach, and Industry 5.0. The analysis reveals that contemporary digital workplaces reproduce the core logic of scientific management through data-driven monitoring and algorithmic decision-making while simultaneously creating new challenges for worker agency, dignity, and meaningful work. To address the limitations of existing theoretical perspectives, the paper proposes the concept of **Optimum Labour Autonomy**, which conceptualizes labour autonomy as a dynamic balance between managerial coordination and employee discretion. The study argues that sustainable organizational performance depends not on maximizing either control or autonomy but on optimizing their interaction. By integrating historical and contemporary labour theories into a unified analytical framework, this research advances the literature on labour governance and provides a novel theoretical foundation for understanding the future of work in increasingly digital and human-centred production systems.

**Keywords:** Digital Taylorism, Labour Autonomy, Algorithmic Management, Industry 5.0 etc.

## 1. Introduction

The history of industrial production is fundamentally the history of unresolved tensions between organizational efficiency and labour autonomy. Despite the technological innovations and enhanced productivity, this relationship between the managerial control and worker autonomy remains unsettled. The origin of this asymmetry can be traced to the Watertown Arsenal controversy of 1911, where the Taylor's stop watch based time and motion studies are contested. A century later, the Algorithmic Governance of the Industry 4.0 echo Taylorist principles for the worker surveillance and performance

control. The similarities between the Taylorism and digital Taylorism manifests the persistence of this lingering friction across different historical periods. (Braverman, 1974; Moore, Upchurch & Whittaker, 2018)

Originating in Britain, the first industrial revolution centralized the production units and labour become increasingly specialized (Mokyr, 1990). The rise of manufacturing industries ultimately led to drastic changes in production methods and managerial control. Taylorism became the new norm, by replacing system before man. He believed in scientific selection and progressive development of the workman by mental revolution. He introduced the 'one best way' where every piece of work can be analysed with scientific measurement and standardization (Taylor, 1911). With this principles, Henry Ford adopted the moving assembly lines which further revolutionized production with high volume output (Hounshell, 1984). Although this contributed to rising wages, the labour unions advocated for improved working conditions and more worker participation in institutional decision making. Furthermore, the lean production systems of the Japanese manufacturers which is even more flexible and efficient are criticized for its managerial tools for performance monitoring and reduced manual labour dependence (Castells, 1996).

Even though the Industry 4.0 promised greater efficiency and operational efficiency, the algorithmic management echo Taylor's principles, which undermines the worker discretion and in the name of supervisory observation. This promises that the automation and remote work enable decentralization which adds to better efficiency in production systems (Schwab, 2016; Brynjolfsson & McAfee, 2014). The contemporary globalized world utilizes digital technology for evaluating and coordinating work (Brown, Lauder & Ashton, 2011). Despite it's promises the algorithmic management and persistent monitoring establishes the modern age version of Taylorism called digital Taylorism (The Economist, 2015a). This concept is so much relevant since the gig economy and platform works is ever expanding. (Wood et al., 2019) The algorithmic asymmetry faced by the gig economy where the workers enjoy flexibility but with significant digital control presents a central paradox of new age work dynamics (Rosenblat and Stark, 2016)

Rather than the disappearance of the Taylorism, gig economy stands as a contemporary extension of scientific management where they codify the work through digital platforms which determines the amount of work as well as assess the performance along with disciplinary actions (Kellogg et al., 2020) The digital paradigms of Industry 4.0 thus revived the new forms of Taylorism through its digital control and management, thereby reducing labour autonomy. This illustrates how the unending dispute between the managerial control and labour autonomy evolved. Therefore, it is essential to enhance the knowledge systems regarding how the employee and employer perceives the same work and how far their perceptions can affect the productivity and efficiency of the system. Hence, this paper addresses the pertinent question, 'to what extent do Industry 4.0 represents a continuation of Taylorist principles?'. This paper also examines the implications these developments have for the future of work in digitally mediated workplaces.

## **2. Review of literature**

Frederick Winslow Taylor's Principles of Scientific Management is the foundational text which shed lights upon the implicit minimum interaction of employment relationship (Littler, 1978). He introduced time and motion studies and the 'one best way' of performing tasks within the manufacturing industry. He believed that there are no inherent conflicts of interest between the employer and employee, the long run

prosperity of both the categories depends upon by putting the system first (Taylor, 1911). Critics argued that this scientific management established managerial control through scientific measurement reduces worker discretion. The Watertown Arsenal controversy, in Massachusetts was early evidence of conflict between efficiency and labour autonomy, which documented the worker resistance to stopwatch-based performance measurement since they perceive it as intrusive and dehumanizing (Aitken, 1960). In spite of aggressive automation, the fundamental concern of labour control remains central to all organizations (Thompson and McHugh, 1995). The disconnected capitalism further deepened and strained the employment relationship and control remains central to every organization (Thompson, 2003). They argue that technological advances overall economic efficiency even though it restructures labour relations (Mokyr, 1990).

The development of the assembly lines of by Ford transformed the industrial organization through large scaled mechanized production systems. He argued that the industrial efficiency can be achieved through improving workflow efficiency and standardization (Ford, 1922). They argue that technological advances overall economic efficiency even though it restructures labour relations (Mokyr, 1990). But the critics argued that the mass production Fordist factory system is the bureaucratization of Taylorism (Hounshell, 1984). Critics challenged his mechanistic assumptions of Taylorism emphasizing the relevance of social relations at workplace (Mayo, 1933; Blauner, 1964). This transformed complex tasks into highly specialized and repetitive operations reducing production costs by escalating managerial control (Gramsci, 1971).

The Labour Process Theory further led to broader understanding of the labour through a sociological perspective. The labour deskilling in capitalist production systems leads to increased labour control (Braverman, 1974). These organizations granted limited autonomy through responsible autonomy where alternative control systems co-exist (Friedman, 1977). This workplace control is hence differentiated into direct, technical and bureaucratic control (Edwards, 1979) and along with this, the workers sometimes participate in the control systems where the consent replaces coercion unintentionally reinforcing the structures that limit their autonomy (Burawoy, 1979). Hence, the autonomy in modern workplaces is paradoxical in which they enjoy flexibility with increased accountability and performance pressures and masks the control as mechanisms of empowerment (Fleming, 2021).

Furthermore, the global economic crises of the 1970s exposed the failures of mass production systems and shifted to a 'second industrial divide'. This is characterized by flexible specialization as an alternative production paradigm which departed from Taylorism and increased labour autonomy (Piore and Sabel, 1984). Contrary to the deskilling thesis, others scholars argued that automation increases the worker autonomy due greater worker responsibility and integrated jobs (Kern and Schumann, 1987). With the evidences from Japanese lean manufacturing which outperformed the fordist mass production systems, the Taylorism is evolved into more collaborative organizational forms presenting a synthesis of efficiency and participation (Womack et al., 1990; Adler, 1993). Along with this line, the high-performance work system model contrast with traditional Taylorist assumptions by giving more thrust to teamwork, participation and continuous improvement (Appelbaum et al., 2000).

The concept of informing is the pioneer of digital Taylorism where the technology can empower the employee and strengthens the employer at the same time. Hence, the immense operational information makes the managerial control more optimized (Zuboff, 1988). Furthermore, the emergence of the network society where technology becomes the infrastructure altered the nature of work and organizational control. The flexible production systems and transformation of work to a globally distributed but digitally

coordinated labour markets resulted in information-based managerial control (Castells, 1996). The technology replaces routine tasks and complements non-routine cognitive work changing the skill demand leading to employment polarization (Autor et al., 2003). This intensifying work contributed to higher levels of worker effort and competition pressure along with reduced work-life balance and employee well-being (Green, 2004). Also, the global competition for skilled labour resulted in declining value of credentials and reduced bargaining power (Brown et al., 2011).

Hence, this rapid technological progress, automation of cognitive tasks, human-machine complementarity, skill-based technological change as well as labour market polarization therefore presents a practical realization of the Second Machine Age (Brynjolfsson & McAfee, 2014) and a fourth Industrial Revolution (Schwab, 2016). The Economist (2015) popularized the concept of Digital Taylorism as the modernized version of Scientific Management which revived the Taylor's principles in digital form by measuring and standardizing and optimizing work through technology. They continuously collect data on workers through data driven workplace surveillance (Moore et al., 2018) and establishes algorithmic management replacing traditional supervisory functions (Leonardi, 2021). Thus, the organizations use the workforce analytics and employee data throughout the employee lifecycle which shows a technological evolution of Taylorism rather than a departure (Meijerink & Bondarouk, 2021). Thus, the supervisory authority is increasingly delegated to artificial intelligence (Kellogg, 2022) and introduces it as an alternative governance model (Jarrahi et al., 2023). This substantiates digital Taylorism as an international policy concern requiring labour regulation emphasizing the relevance of human-centered governance (Eurofound, 2023; ILO, 2024; OECD, 2024; WEF, 2025).

Even though the literature comprehensively assesses the historical evolution of Taylorism to the Industry 4.0, several gaps exist. The lack of historical continuity across revolutions is the first and foremost gap with the existing literature. The fragmented understanding of labour autonomy does not explain how the labour autonomy evolved over these separate historical phenomena. The absence of theoretical integration of labour with industry 4.0 further over-emphasizes the gig-economy and platform work, which is just a part of the whole picture of digitally segmented work. The insufficient multi-level perspective on managerial control is very significant methodological gap. The literature does not have macro-level, meso-level and micro-level perspectives of labour autonomy and limited empirical examination of employer and employee orientation. The absence of quantitative measurement and limited evidence from emerging economies consequently demands a genuine assessment of the Industry 4.0 as a transformation of work and labour autonomy.

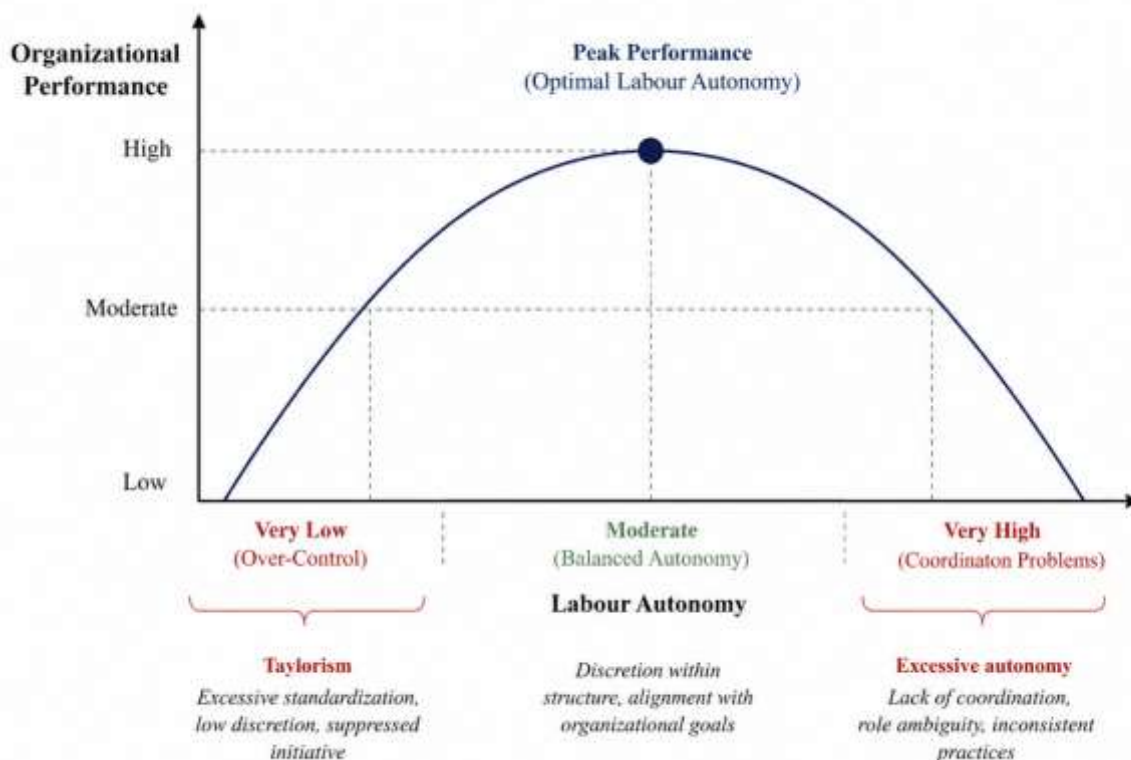
### 3. Theoretical Framework

The study applied an integrative theoretical approach where labour autonomy becomes the central construct. From early critiques of capitalism to the digital Taylorism, labour autonomy has dual orientations. The instrumental orientation views the labour autonomy as a management tool to improve the institutional performance and the emancipatory orientation treats it as the freedom and control of worker agency over the labour processes. Hence, there should be an optimum point where this labour autonomy should function. At this point, the organizational goals are clear as well as the employer discretion will be within defined boundaries. Hence, the study theoretically moves beyond 'more autonomy better' assumption to how much autonomy will boost the organizational efficiency. Theories from the instrumental orientations and worker orientations are hence, considered for the examination of the optimal labour autonomy. The theories from instrumental orientation include Human Relation Theory,

Socio-Technical Systems theory, Job Characteristics model and High Commitment Human Resource Management. Despite these theories which assumes that the autonomy increases productivity, the other spectrum of theories which include Marxian theory, Labour Process Theory, Self-determination theory and Capability Approach assumes autonomy preserves dignity of men at work and supports democratic workplaces.

The theories with instrumental orientation perceive as a means to improve worker morale, adaptability, sustainable performance and organizational commitment. The labour autonomy is reflected through employee participation, communication, consultation and involvement in decision-making which further contributes to productivity enhancement (Mayo, 1933; Roethlisberger & Dickson, 1939). Unlike Taylorism, autonomy is assessed through degree of self-management, team decision authority, adaptability and coordination, thereby enhancing efficiency with jointly optimized technical systems and social systems (Trist & Bamforth, 1951; Emery & Trist, 1960). Higher autonomy is expected to increase the intrinsic motivation, responsibility, job satisfaction and work performance and is one among the core job characteristics (Hackman & Oldham, 1976). Therefore, the labour autonomy is viewed as a strategic HR practice where the thrust is building long-term relationships based on trust, empowerment and discretionary effort rather than strict supervision (Guest, 1987; Storey, 1992; Purcell, 1999).

On the other way, the emancipatory orientations give thrust to worker discretion, control over work methods, participation in decisions, resistance and freedom of labour. Here, the labour autonomy is inherent and preserve worker dignity. The control over the production defines the labour autonomy and an externally imposed labour reduces the ownership of labour (Marx, 1867). Consequently, labour autonomy is manifested through decision latitude and resistance to managerial domination (Braverman, 1974).



**Figure 1: Optimum Labour Autonomy**

Moreover, the autonomy is one of the three fundamental psychological need of a worker along with competence and relatedness. This perceived choice, volition, self-direction, intrinsic motivation and perceived control is so detrimental in their job performances (Deci & Ryan, 1985/2017). The Capability Approach extends the labour autonomy to that extend where the worker possesses the capability to choose and opportunity to meaningful work. Hence, the primary concern of the emancipatory orientation is freedom from alienation, resistance to managerial domination, intrinsic motivation and human development.

Thus, the two different orientations suggest that there should be balance between the employee discretion and organizational efficiency. Hence, the study proposes an optimum labour autonomy (Figure 1) by integrating the traditional assumptions of the organizational practices with worker freedom for a sustainable workplace which can ensure organizational efficiency, employee well-being and sustainable performance. This optimum is so crucial for the modern dynamic labour markets which requires to keep flexibility and security simultaneously.

#### 4. Methodology

The study examines the evolution of labour control and autonomy to assess the extend of continuation of the Taylorist principles in the modern digital era, hence it employs an interpretivist approach which is analytical in nature. Thus, the paper adopts a qualitative and amalgamates historical evidences with contemporary conceptual constructs to absorb the transformations in labour autonomy. The systematic literature review is hence chosen to critically evaluate the evolution and reduce the selection bias to retain the credibility of the information retrieved. Therefore, the study is descriptive as well as exploratory enabling in describing the essence of both Taylorism and digital Taylorism.

Thus, the study depends solely on secondary data retrieved from from peer-reviewed journal articles, books, conference proceedings, policy reports, and publications from international organizations. Major academic databases including Scopus, Web of Science, JSTOR, ScienceDirect, SpringerLink, Emerald Insight, Taylor & Francis Online, Wiley Online Library, JSTOR and Google Scholar were consulted to identify relevant literature. Reports published by organizations such as the International Labour Organization (ILO), Organization for Economic Co-operation and Development (OECD), World Economic Forum (WEF), and European Commission were also reviewed to obtain contemporary evidence on digital labour management and Industry 4.0.

The search strategy using Boolean operators. Primary search terms included "Taylorism," "Scientific Management," "Digital Taylorism," "Industry 4.0," "Algorithmic Management," "Algorithmic Governance," "Labour Process Theory," "Labour Autonomy," "Worker Surveillance," "Platform Work," "Gig Economy," "Future of Work," "Digital Labour," and "Managerial Control." Searches were refined using combinations such as Taylorism AND Industry 4.0, Digital Taylorism AND Labour Autonomy, and Algorithmic Management AND Gig Economy. Reference lists of highly cited studies were further examined to identify additional relevant publications through backward citation searching. Priority was given to peer-reviewed publications and influential theoretical works that significantly contributed to understanding the evolution of managerial control. Historical sources such as Taylor (1911), Braverman (1974), and Hounshell (1984) were retained because of their foundational importance. Publications lacking scholarly rigor, opinion pieces without empirical or theoretical support, duplicate studies, and literature unrelated to labour control or Industry 4.0 were excluded from the review.

The collected literature was analysed using thematic analysis supported by historical comparison. Initially,

the selected publications were read in detail to identify recurring concepts related to managerial control, worker autonomy, technological surveillance, efficiency, standardization, algorithmic governance, and digital labour. Similar concepts were grouped into broader analytical themes, including scientific management and labour control, Fordism and mass production, lean production and participative control, algorithmic management, digital Taylorism, and the future of labour autonomy. These themes were subsequently compared across historical periods to identify patterns of continuity and transformation.

A historical-comparative framework was employed to examine whether the principles underlying Taylor's Scientific Management continue to exist within contemporary digital workplaces. Particular emphasis was placed on analysing how technological developments have altered the mechanisms of managerial control while retaining many of the fundamental assumptions of scientific management. To enhance the credibility of the findings, evidence was triangulated across multiple scholarly sources representing economics, sociology, industrial relations, labour process theory, management, and information systems. Preference was given to highly cited publications and authoritative institutional reports. The use of multiple databases, explicit inclusion criteria, and a transparent search strategy improves the reliability and replicability of the review process while reducing publication and selection bias. Nevertheless, academic integrity was maintained throughout the research by accurately citing all original sources and avoiding plagiarism. The review was conducted objectively, ensuring that contrasting theoretical perspectives on labour autonomy and managerial control were represented fairly to provide a balanced interpretation of the evolution from Taylorism to digital Taylorism.

## **5. Analysis**

The relationship between the managerial control and labour autonomy has been synthesized through the historical evolution of discontinuous technological revolutions. The study argues that the fundamental managerial objectives of efficiency maximization were stable over the period of time, while the labour autonomy has been so dynamic. The Industry 4.0 is best understood as the latest manifestation in a long historical trajectory of scientific management. This challenges the scholarship which considers that the digitalization enhances the labour autonomy (Brynjolfsson & McAfee, 2014; Schwab, 2016). This section hence synthesizes the study's findings on the relationship between digital transformation and managerial control. It traces continuity from scientific management through digital Taylorism and algorithmic governance, weighs this against contrary evidence of genuine worker empowerment, and proposes an Optimum Labour Autonomy framework specified in terms that can be empirically tested rather than merely asserted. The chapter closes by identifying the limits of the evidence base on which these claims rest.

### **5.1. Historical Continuity of Managerial Control**

Industrial development is better understood as a continuous evolution of managerial control than as a sequence of disconnected technological revolutions. Although successive industrial revolutions have transformed production technologies—from mechanization and electrification to mass assembly, automation, cyber-physical systems, and artificial intelligence—the underlying objective of management has remained largely unchanged: to enhance organizational efficiency through the systematic coordination and regulation of labour. The transition from Taylorism to Industry 4.0 should therefore be interpreted not as a discontinuous technological rupture but as an evolutionary transformation in the mechanisms through which managerial control is exercised. This reading challenges technologically deterministic narratives that portray digitalization as inherently decentralizing organizational authority and empowering workers

(Brynjolfsson & McAfee, 2014; Schwab, 2016).

Scientific management constituted the first systematic attempt to institutionalize this managerial rationality. Taylor (1911) argued that industrial inefficiency stemmed from worker discretion, informal work practices, and the absence of standardized methods, and proposed transferring production knowledge from workers to management through scientific observation, task decomposition, and time-and-motion study. The "one best way" was thus more than a technical innovation; it embodied a new form of organizational governance in which managerial expertise displaced workers' experiential knowledge as the principal source of production authority. The Watertown Arsenal controversy illustrates why this was contested: workers interpreted stopwatch-based observation as an instrument of managerial domination rather than a neutral productivity improvement (Aitken, 1960). Fordism subsequently embedded similar principles into the assembly line, while Human Relations, socio-technical systems theory, and lean production softened the interpersonal texture of managerial practice without abandoning coordinated efficiency as an objective. Industry 4.0 extends this trajectory rather than breaking from it.

### **5.2. Digital Taylorism as Computational Scientific Management**

Artificial intelligence, cyber-physical systems, digital twins, enterprise platforms, wearable technologies, and predictive analytics increasingly perform supervisory functions once carried out by human managers. Reviewing the literature on algorithmic management, Parent-Rochelleau and Parker (2022) identify six managerial functions that are now routinely delegated to algorithms: monitoring, goal setting, performance evaluation, scheduling, compensation, and termination decisions. This is a more specific and verifiable claim than the general assertion that "algorithms manage workers": it identifies which functions have migrated to software and provides a basis for testing how far that migration has progressed in any given organization.

Labour Process Theory offers one explanation for this shift. Braverman (1974) argued that capitalist production continually restructures labour processes by transferring production knowledge from workers to management, separating conception from execution. Contemporary algorithmic systems extend this principle by codifying operational expertise into software capable of directing production with limited human mediation. Unlike classical Taylorism, digital Taylorism is continuous and predictive rather than periodic: intervention shifts from retrospective inspection toward anticipatory flagging of deviations before they affect output. Whether this constitutes an intensification of managerial capacity, as Braverman's framework predicts, or a redistribution of decision-making that also benefits workers is precisely the question addressed in the following section, where the evidence is more mixed than a straightforward extension of Labour Process Theory would suggest.

### **5.3. Labour Autonomy: Weighing the Evidence**

The literature on algorithmic management does not speak with one voice, and this study treats that disagreement as a finding in itself rather than resolving it by assumption. One body of evidence supports the control thesis. Kinowska and Sienkiewicz's (2023) survey of European organizations found that algorithmic management practices were associated with reduced job autonomy and, through that pathway, with lower workplace well-being. In the gig economy, Wood et al. (2019) and Kellogg et al. (2020) similarly document how workers who gain temporal flexibility over when to work remain subject to algorithmic allocation of tasks, dynamic pricing, and automated evaluation over which they have little influence.

A second body of evidence complicates this picture. Kaasinen et al. (2020), studying Operator 4.0 implementations across several manufacturing companies, found that workers largely welcomed digital

tools that adapted the shop floor to their skills and gave them a role in designing their own work processes, though the same respondents expressed reservations about the monitoring components of these systems. Separately, Cameron and Rahman (2022) show that platform workers are not passive subjects of algorithmic control: their study of ride-hailing and freelance platforms documents how workers actively screen customers, time their availability, and contest unfavourable ratings, meaning that algorithmic systems constrain but do not eliminate worker agency.

Reconciling these findings requires a more precise distinction than "autonomy versus control." This study distinguishes procedural autonomy—discretion in how an assigned task is executed—from institutional autonomy, which concerns influence over organizational rules, production priorities, and strategic decisions. Read through this distinction, the empowerment findings of Kaasinen et al. (2020) and the resistance tactics documented by Cameron and Rahman (2022) are consistent with the control findings of Kinowska and Sienkiewicz (2023): workers gain real procedural latitude and retain the capacity to act within the system, while the parameters of the system itself—targets, sequencing, and evaluation criteria—remain outside their influence. The two literatures are therefore not straightforwardly contradictory; they are documenting different levels of the same organizational structure, and future research designed explicitly to measure both levels concurrently would test this claim directly.

#### 5.4. From Panopticon to Algorithmic Surveillance

Foucault's (1977) concept of disciplinary power offers an interpretive lens for organizational surveillance under Industry 4.0. Classical scientific management relied on visible, embodied supervision; digital systems instead collect behavioural data continuously through sensors, wearable devices, enterprise resource planning systems, and monitoring platforms, generating information without requiring constant managerial presence. The mechanism through which this affects workers is not merely theoretical: Kinowska and Sienkiewicz (2023) trace an empirical pathway from algorithmic monitoring through reduced perceived autonomy to lower workplace well-being, giving the Foucauldian argument a measurable behavioural correlate rather than leaving it as metaphor alone.

The relevant difference from Bentham's Panopticon is opacity. Employees frequently do not know how performance data are weighted or how algorithmic decisions are generated, a gap documented directly in workers' own accounts of frustration with unexplained rating changes and opaque platform decisions (Cameron & Rahman, 2022). This opacity is a design property of specific systems rather than an inherent feature of digitalization, which matters for the argument developed in Section 4.5: if opacity is a design choice, it is also a variable that organizations can change.

#### 5.5. An Operationalized Optimum Labour Autonomy Framework

The evidence reviewed above indicates that neither unrestricted algorithmic control nor unlimited worker discretion is empirically well supported as the dominant pattern; organizations exhibit both control and latitude simultaneously, distributed across procedural and institutional levels. This study proposes Optimum Labour Autonomy as a framework describing the conditions under which this coexistence produces sustainable performance rather than dysfunction. To move beyond assertion, the framework is specified along four dimensions, each stated so that it could in principle be measured and therefore disconfirmed:

1. **Procedural discretion.** The proportion of task-level decisions (e.g., sequencing, method, pacing within tolerance limits) left to worker judgement rather than fixed by algorithmic instruction, measurable through task audits or instruments such as the Algorithmic Management Questionnaire (Parent-Rocheleau & Parker, 2022).

2. **Institutional voice.** Whether workers or their representatives have a documented channel of input into the design of performance metrics and algorithmic rules that govern them—not merely notification of those rules after the fact.
3. **Explainability.** Whether workers can obtain a comprehensible account of why a specific algorithmic decision (a rating, a scheduling assignment, a flagged deviation) was made, and whether that account can be contested through a defined process.
4. **Well-being outcome.** Whether the combination of the first three dimensions is associated with the well-being and retention outcomes identified by Kinowska and Sienkiewicz (2023) as sensitive to autonomy and monitoring.

On this specification, the framework generates a testable proposition: organizations scoring higher on dimensions 1–3 should show better outcomes on dimension 4 than organizations that are procedurally generous but institutionally closed, or vice versa. This is falsifiable in a way that a general appeal to "balance" between control and autonomy is not. Industry 5.0's emphasis on human-centric, resilient, and sustainable production (European Commission et al. (2021)) provides the policy context in which such a framework would be applied, but the framework's validity is a separate, empirical question from whether Industry 5.0 is adopted as a policy label.

Collectively, these findings indicate that the evolution from scientific management to Industry 4.0 reflects continuity in managerial rationality rather than discontinuity in organizational purpose. Each production paradigm introduced new technologies, yet each also generated new mechanisms for observing, coordinating, evaluating, and optimizing labour; digitalization has therefore intensified rather than resolved the historical tension between efficiency and autonomy identified throughout this analysis. The contribution of the present framework lies in reframing this tension as a design problem rather than as an inevitable conflict between technology and worker interests. Institutions—not technologies in themselves—determine whether digital systems become instruments of domination or enablers of collaborative production. Transparent algorithms, participatory governance, explainable artificial intelligence, worker representation in technological implementation, and ethical data governance can moderate the excesses of digital Taylorism while preserving the operational efficiency that organizations legitimately pursue.

Future empirical research should examine Optimum Labour Autonomy across sectors, organizational sizes, and institutional contexts to identify the combinations of technological capability and worker discretion that maximize sustainable performance. Such an agenda would extend labour process scholarship by shifting attention away from the mere existence of control and toward its quality, legitimacy, and balance in digitally mediated workplaces. The framework also contributes to Industry 5.0 scholarship by positioning labour autonomy as a productive organizational capability rather than merely a normative aspiration (European Commission et al. (2021)): in this sense, worker agency is not opposed to efficiency but constitutes one of its long-term foundations. The analysis therefore concludes that digital transformation should be evaluated not only by productivity gains but also by its capacity to preserve meaningful work, accountability, and democratic participation within technologically advanced production systems. This balanced perspective offers a theoretically grounded basis for understanding the future of work under digital capitalism, and for designing digital production systems that are efficient without being domineering. Ultimately, the value of digital transformation should be judged not solely by its capacity to reduce costs or accelerate output, but by whether it expands or forecloses the space within which workers can exercise judgement, contest decisions, and shape the conditions of their own labour.

## 6. Findings and Discussion

The analysis yields a set of interrelated findings that, taken together, characterize the trajectory of managerial control from classical scientific management to algorithmically mediated production.

Continuity, not rupture, governs the historical trajectory. The evolution of industrial production is more accurately read as a sustained refinement of managerial rationality than as a series of discrete technological breaks. Across successive industrial revolutions, each new production technology has been absorbed into an existing project of labour coordination rather than displacing it; the tools of control have changed while the underlying rationale — extracting greater efficiency through finer-grained measurement and standardization — has not (Braverman, 1974; Thompson & McHugh, 2009).

Industry 4.0 is the institutional heir of Taylorism, not its supersession. The substitution of stopwatch-based supervision with artificial intelligence, cyber-physical systems, and predictive analytics represents a change in instrumentation rather than in objective. Taylor's (1911) ambition to reduce production to a scientifically determined "one best way" persists in digital form: the target of optimization remains labour, and the method remains systematic measurement, even as the apparatus has become computational rather than manual (Moore et al., 2018).

Control has migrated from direct supervision to algorithmic governance. Rather than being exercised episodically through a supervisor's presence, managerial authority is now distributed across computational infrastructures that monitor, evaluate, and coordinate labour continuously and in real time — extending the reach of control while making it less attributable to any single decision-maker (Kellogg et al., 2020).

Digital empowerment is real but bounded. The evidence does not support a simple narrative of disempowerment: digital tools genuinely expand workers' access to information and decision-support capacity, and are in some contexts experienced by workers as improving the quality of their work (Kaasinen et al., 2020). What the findings do not support is the further inference that this translates into expanded strategic influence — production targets and performance thresholds remain algorithmically set, so empowerment and centralization coexist rather than substitute for one another.

Labour autonomy has been reconfigured along a procedural–institutional axis, not simply expanded or contracted. Industry 4.0 measurably increases discretion in how a task is executed while constraining influence over the rules that define acceptable performance. This distinction accommodates findings of both worker empowerment (Kaasinen et al., 2020) and worker resistance (Cameron & Rahman, 2022) without treating either as anomalous.

Surveillance has become the contemporary mechanism of Taylorist control, distinguished from its predecessors by opacity rather than intensity. Integrating Labour Process Theory with Foucauldian disciplinary power clarifies that workplace surveillance has shifted from visible, embodied observation to continuous, data-driven monitoring that workers can rarely inspect or contest (Braverman, 1974; Foucault, 1977).

Algorithmic management institutionalizes managerial knowledge; it does not eliminate management as a function. What changes is the visibility of hierarchy: intervention once personally exercised is now embedded in infrastructure, reducing its salience to workers without reducing its effect (Kellogg et al., 2020; Moore et al., 2018).

Industry 5.0's human-centric orientation is a normative aspiration, not a structural resolution. Whether human-centred manufacturing is realized in practice depends on the governance structures adopted, rather than on technological capability or policy language alone (European Commission et al., 2021).

Sustainable performance depends on institutional equilibrium, not on maximizing either control or autonomy — the basis for the Optimum Labour Autonomy framework advanced in this study. The study's principal theoretical contribution is the integration of these strands into a single explanatory framework, positioning labour autonomy — specified along procedural and institutional dimensions — as the variable through which digital production systems might reconcile efficiency with human-centred work.

The findings of this study indicate that the movement from classical Taylorism to digital Taylorism constitutes not a paradigmatic rupture but a technological reconfiguration of the mechanisms through which labour is organized, monitored, and controlled. Whereas Taylor's (1911) scientific management sought to maximize productivity through standardized methods, time-and-motion analysis, and hierarchical supervision, Industry 4.0 extends these same ambitions through algorithmic management, artificial intelligence, cyber-physical systems, and continuous digital surveillance. The tension between organizational efficiency and labour autonomy first exposed by the Watertown Arsenal controversy has therefore not been resolved so much as re-articulated in increasingly sophisticated technical form. This persistence corroborates Braverman's (1974) central claim in Labour Process Theory: that technological advancement functions primarily to restructure the terms of managerial control rather than to dissolve the conflicts inherent to the employment relationship itself.

The analysis further demonstrates that digital technologies have intensified labour control by embedding surveillance within the production system rather than leaving it dependent on direct supervisory presence. The Internet of Things, wearable devices, predictive analytics, and automated performance monitoring together generate a continuous evaluative record of worker behaviour, productivity, and compliance. These developments substantiate Foucault's (1977) account of disciplinary power, in which surveillance becomes internalized and workers regulate their own conduct under the perceived, rather than actual, presence of observation. Where classical Taylorism depended on visible supervisors and stopwatch measurement, digital Taylorism institutionalizes governance that is invisible, continuous, and data-driven. Managerial authority thus increasingly operates through algorithmic mediation rather than individual oversight, simultaneously expanding organizational capacity to standardize the labour process and narrowing the discretion available to those who perform it.

Nevertheless, the findings caution against equating comprehensive managerial control with sustainable organizational performance. Intensive surveillance, rigid algorithmic decision-making, and diminished discretion may yield short-term operational gains while eroding the conditions on which longer-term performance depends. This pattern is consistent with a body of organizational theory that, despite disciplinary differences, converges on a common proposition: that meaningful autonomy is a precondition for engagement, learning, and innovation rather than an obstacle to efficiency. Self-Determination Theory identifies autonomy, alongside competence and relatedness, as a basic psychological need whose frustration undermines intrinsic motivation (Deci & Ryan, 2000); the Capability Approach reframes such autonomy as a substantive freedom constitutive of human development rather than a discretionary managerial concession (Sen, 1999); the Human Relations tradition demonstrated empirically that productivity is shaped by social and psychological conditions of work, not by technical arrangement alone (Mayo, 1933); Socio-Technical Systems Theory showed that production outcomes depend on the joint optimization of technical and social systems rather than the technical system in isolation (Trist & Bamforth, 1951); and the Job Characteristics Model specifies autonomy as one of the core task properties through which work becomes internally motivating (Hackman & Oldham, 1976). Read together, this

convergence across otherwise distinct theoretical traditions suggests that neither unrestricted managerial control nor unbounded worker autonomy constitutes an optimal organizational arrangement.

The principal theoretical contribution of this study is the conceptualization of Optimum Labour Autonomy, which synthesizes the instrumental and emancipatory traditions of labour theory into a single analytical framework. Rather than treating autonomy as a binary condition—either subordinated to managerial prerogative or fully emancipated from it—the framework specifies autonomy as a continuum along which organizational efficiency and worker agency can, in principle, be jointly optimized rather than traded off against one another. At this equilibrium, sufficient managerial coordination is retained to secure operational objectives, while sufficient discretion is preserved to sustain adaptive decision-making, learning, and human dignity. This reframing advances existing labour theory by displacing the assumption that either maximizing control or maximizing autonomy, pursued independently, yields superior organizational outcomes.

The study also situates itself within the emerging literature on Industry 5.0 by positioning human-centred production as a corrective response to the structural limitations of digital Taylorism. Where Industry 4.0 privileges technological optimization and algorithmic efficiency as ends in themselves, Industry 5.0 advances a model of collaborative intelligence in which advanced technologies augment rather than supplant human judgement, creativity, and professional autonomy (European Commission et al., 2021). The Optimum Labour Autonomy framework aligns with this orientation by proposing that digital transformation ought to be evaluated not solely against productivity indicators, but against its capacity to preserve meaningful work, employee well-being, ethical governance, and organizational resilience.

Taken as a whole, this study suggests that the future of work is better characterized not as a transition from Taylorism to some post-Taylorist condition, but as an evolution from mechanical control to algorithmic governance. The enduring challenge facing organizations is accordingly not the adoption of advanced technology per se, but the design of governance arrangements capable of reconciling efficiency with autonomy. By integrating Taylorism, Labour Process Theory, Foucauldian surveillance, algorithmic management scholarship, and the Industry 5.0 agenda into a coherent theoretical model, this study offers a novel foundation for understanding labour governance under digital capitalism. Optimum Labour Autonomy thereby constitutes both a theoretical advance and a practical orientation for organizations seeking to reconcile sustainable productivity with worker dignity, participation, and democratic engagement in increasingly digitalized workplaces.

## **7. Conclusion**

The findings developed in previous section are subject to a set of limitations that qualify their scope and should inform how they are read and subsequently tested.

The findings are conceptually derived rather than empirically validated. The relationships proposed between Taylorism, digital Taylorism, algorithmic governance, and labour autonomy are the product of theoretical synthesis rather than primary data collection. The Optimum Labour Autonomy framework is accordingly best understood as a set of testable propositions rather than an established finding; its explanatory value depends on empirical validation across organizational and industrial contexts that this study has not itself undertaken.

The analysis is disproportionately grounded in manufacturing. The historical narrative traces the evolution of industrial production from scientific management to Industry 4.0, a lineage most directly applicable to manufacturing settings. Although several arguments plausibly extend to service and platform economies

— and indeed draw on gig-economy evidence (Kellogg et al., 2020; Wood et al., 2019) — their transferability to knowledge-intensive, creative, or professional-service industries, where the labour process is less amenable to task decomposition, has not been established and should not be assumed.

The analysis privileges managerial control over the mechanisms by which workers contest it. While labour autonomy is treated as a counterweight to algorithmic governance, the study affords comparatively limited attention to collective bargaining, trade union representation, and the informal resistance tactics through which workers actively reshape algorithmic systems in practice (Cameron & Rahman, 2022). A fuller account of the control–autonomy relationship would need to treat worker agency not merely as a residual space left open by managerial design, but as an active force that itself alters how that design evolves.

Algorithmic management is treated with more internal coherence than organizational practice is likely to exhibit. The framework implicitly assumes a relatively uniform system of algorithmic governance, whereas organizations differ substantially in technological capability, governance maturity, regulatory exposure, and the fidelity with which digital tools are actually implemented. The intensity and consequences of algorithmic control should therefore be expected to vary considerably across firms and sectors, and the framework's uniformity is a simplification rather than an empirical claim about convergence.

The procedural–institutional distinction remains conceptually productive but empirically underspecified. Although differentiating discretion over task execution from influence over organizational governance sharpens the theoretical account of autonomy, the distinction has not yet been operationalized into reliable measurement scales. Existing instruments such as the Algorithmic Management Questionnaire (Parent-Rocheleau & Parker, 2022) offer a plausible starting point, but their capacity to capture the institutional dimension specifically — as opposed to procedural discretion alone — has not been demonstrated and would require dedicated scale-development work.

Cross-national institutional variation is largely absent from the analysis. Labour regulation, industrial relations systems, and collective governance arrangements differ substantially across national contexts (Hall & Soskice, 2001), and these differences plausibly condition how digital Taylorism unfolds — for instance, through works councils' rights to co-determine the introduction of monitoring technology, or through variation in dismissal protections that affect how consequential algorithmic evaluation becomes. The present analysis does not account for this institutional heterogeneity and its conclusions should be treated as most applicable to the regulatory contexts from which the underlying literature is drawn.

Industry 5.0 is examined primarily as a normative orientation rather than an empirically verified corrective. The human-centric vision articulated in EU policy discourse (European Commission et al., 2021) offers an alternative framing for industrial development, but evidence on its implementation and long-term effectiveness remains limited. Whether Industry 5.0 principles measurably mitigate algorithmic control, as opposed to reframing it rhetorically, is an empirical question this analysis does not resolve.

Optimum Labour Autonomy identifies an equilibrium concept without specifying universal thresholds. The framework proposes that sustainable performance depends on calibration between managerial coordination and worker discretion, but it does not — and, given current evidence, cannot — specify where that calibration point lies for a given industry, technology, or occupational group. The framework is therefore properly read as a guiding heuristic for organizational design and future research rather than as a prescriptive standard with fixed parameters.

Despite the limitations, the findings suggest that the passage from classical to digital Taylorism marks not a rupture but a reconfiguration of how labour is organized, monitored, and controlled. Taylor's (1911)

pursuit of productivity through standardization and hierarchical supervision persists in Industry 4.0's algorithmic management, cyber-physical systems, and continuous surveillance; the tension exposed by the Watertown Arsenal controversy has been re-articulated in more sophisticated technical form rather than resolved, affirming Braverman's (1974) claim that technological change restructures managerial authority more than it dissolves employment conflict.

This restructuring operates increasingly through embedded rather than embodied observation. Sensors, wearables, and predictive analytics generate a continuous evaluative record of worker conduct, exemplifying Foucault's (1977) disciplinary power: surveillance becomes internalized, and workers self-regulate under its perceived rather than actual presence. Yet the evidence resists equating intensified control with sustainable performance. Diminished discretion may secure short-term efficiency while eroding the conditions—*intrinsic motivation* (Deci & Ryan, 2000), *substantive freedom* (Sen, 1999), *social conditions of productivity* (Mayo, 1933), *joint technical-social optimization* (Trist & Bamforth, 1951), and *motivating task design* (Hackman & Oldham, 1976)—on which longer-term commitment and innovation depend.

Synthesizing these traditions, the study's central contribution, *Optimum Labour Autonomy*, reframes autonomy as a calibrated equilibrium rather than a binary outcome: sufficient coordination to secure organizational objectives, sufficient discretion to sustain judgement and dignity. This reframing aligns with Industry 5.0's aspiration toward human-centred, augmentative technology (European Commission et al., 2021), though its realization remains a governance choice rather than a technological guarantee. The future of work, accordingly, turns less on adopting advanced systems than on designing governance that reconciles efficiency with autonomy.

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