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The Economics Of Algorithmic Management: The Impact Of AI Surveillance On The Marginal Productivity Of Gig Workers

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Abstract

This research investigates the microeconomic impact of AI-driven surveillance on the marginal productivity of gig workers, addressing a critical gap in neoclassical labor models. While conventional paradigms assume that algorithmic monitoring linearly enhances output, this study introduces the "Algorithmic Fatigue" construct as an endogenous frictional variable that artificially engineers premature diminishing returns. Utilizing a high-powered sample of 1,200 ride-hailing drivers in Jabodetabek, the study employs a hybrid methodological approach integrating Partial Least Squares Structural Equation Modeling (PLS-SEM) and Non-linear Least Squares (NLS) regression. The empirical results reveal a paradoxical architecture: while AI intensity provides a weak direct productivity impetus (β = 0.118), it simultaneously triggers a massive negative indirect effect mediated by algorithmic fatigue (β = -0.415). Econometric simulations demonstrate that the labor duration viability threshold (L) collapses precipitously from 14.8 hours in low-surveillance environments to a mere 3.3 hours under aggressive algorithmic regimes. Beyond this critical inflection point, workers enter a deficit zone of negative marginal productivity ($MP_L < 0$) characterized by "Red Queen Dynamics" and maladaptive resistance behaviors, such as GPS spoofing and cognitive paralysis. The study concludes that algorithmic management ultimately cannibalizes its own efficiency by destroying the neurocognitive infrastructure of human capital. These findings necessitate an urgent paradigm shift toward cognitive-ecological justice and the implementation of specific labor protections, including the "right to disconnect" and algorithmic transparency mandates.*

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Keywords: ***Algorithmic Management, Algorithmic Fatigue, Marginal Productivity, Gig Economy, Red Queen Dynamics.***

INTRODUCTION

The global macroeconomic landscape and contemporary labor market structures are currently undergoing fundamental transformations and structural disruptions driven by the rapid acceleration of digital technologies. At the forefront of this transition, platform-mediated gig economy business models have evolved from a peripheral phenomenon into a central pillar of global employment architecture. In the context of Indonesia, this phenomenon is distinctly manifested through the deep market penetration of decacorn technology platforms such as Gojek and Grab, which have generated millions of informal employment opportunities within the ride-hailing and on-demand logistics sectors (Muhyiddin et al., 2024). Recent estimates indicate that Indonesia's gig economy ecosystem currently engages millions of workers who derive their primary livelihood from smartphone-mediated daily mobility (Putri et al., 2023). Nevertheless, beneath the emancipatory rhetoric of temporal flexibility, worker autonomy, and micro-entrepreneurship championed by corporate entities, empirical realities reveal an industrial relations dynamic that is fundamentally more complex, highly asymmetric, and fraught with precarity (Budiono, 2023). These platforms implement systems academically recognized as 'Algorithmic Management,' whereby traditional managerial functions—ranging from task allocation and dynamic pricing to performance evaluation and even account deactivation (suspension)—are wholly delegated to Artificial Intelligence (AI)-driven software and big data analytics (Mufti et al., 2026).

The current state of the literature indicates that the discourse surrounding the impacts of AI-driven workplace surveillance has garnered broad interdisciplinary attention, reflecting both the theoretical and practical urgency of the phenomenon. From the perspectives of Critical Platform Studies and the sociology of work, the dominant literature primarily focuses on the legal ambiguity of gig workers' employment status. A majority of studies highlight the paradox of 'bogus self-employment' (disguised employment), wherein workers are legally classified as 'partners' or independent contractors (under Indonesia's Law No. 20 of 2008 concerning Micro, Small, and Medium Enterprises), yet remain materially subjected to stringent prescriptive controls characteristic of subordinate employees, devoid of the statutory social protections mandated by the Manpower Law (Law No. 13 of 2003) (Muhyiddin et al., 2024). Conversely, within the domains of organizational psychology and organizational behavior,

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a growing body of qualitative research and case studies has begun to document the psychosocial ramifications of this human-machine interaction. These studies reveal that gig workers are highly susceptible to chronic stress, emotional exhaustion, and social isolation, stemming from algorithmic controls that function as an invisible, faceless, and relentless 'Digital Boss' (Bowdler et al., 2026). Furthermore, recent scholarship in Information Systems (IS) highlights how algorithmic management has radically reconfigured the architecture of work (algorithms as work designers), thereby engendering pervasive information asymmetries that severely circumscribe worker autonomy and diminish the intrinsic meaning of work (van Zoonen et al., 2023).

Notwithstanding the robust accumulation of knowledge concerning the sociological and psychological vulnerabilities of platform workers, a critical research gap remains inadequately addressed within mainstream economic literature. Prior studies have systematically failed to model and quantify the microeconomic impacts of algorithmically induced stress on fundamental labor efficiency. The majority of labor economics research continues to rely on conventional neoclassical productivity theories, which posit that diminishing marginal productivity is driven exclusively by mechanical-biological fatigue or constraints in physical capital inputs (Qodriyah & Wungu, 2025). These equilibrium models conceptualize surveillance as a neutral instrument that functions linearly to mitigate moral hazard and information asymmetry, thereby operating under the strict assumption that it invariably enhances aggregate worker output (Arief, 2024). This orthodox paradigm entirely disregards the neurocognitive frictions engendered by the digital panopticon. It systematically fails to formalize, either mathematically or prescriptively, the critical threshold at which algorithmically enforced target pressures—mandating real-time interventions such as coercive notifications, relentless GPS tracking, and unilateral rating fluctuations—precipitate a cognitive overload that counterproductively erodes the worker's marginal productivity per additional unit of time.

To address this fundamental gap, this study explicitly declares its novelty by advancing a theoretical and empirical analytical framework detailing the negative inward shift of the marginal productivity curve induced by the phenomenon of 'Algorithmic Fatigue.' This research conceptualizes 'Algorithmic Fatigue' not merely as a latent, isolated psychological variable, but rather as an endogenous frictional variable within the microeconomic labor production function (Yang et al., 2024). Whereas previous scholarship has predominantly engaged in qualitative discourses surrounding labor ethics, human rights, or normative legal frameworks, this article introduces a significant theoretical leap by rigorously analyzing, in strict economic terms, how prescriptive AI

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controls artificially engineer premature diminishing returns. The central thesis underpinning this novelty posits that machine surveillance—once it surpasses a critical cognitive threshold—ceases to function as a catalyst for optimization. Instead, it triggers 'Red Queen Dynamics,' wherein platform efforts to extract surplus value via aggressive algorithmic discipline deplete the mental processing capacity of workers, ultimately resulting in negative marginal productivity for additional hours worked (Yolusever, 2026).

The policy, managerial, and academic significance of this research converges on profound implications for the future governance of digital labor ecosystems. From a managerial standpoint, identifying the upper efficiency threshold of algorithmic control provides a robust empirical foundation and economic rationale for major technology platforms to reevaluate and structurally redesign their user interfaces and decision-making architectures. This necessitates a paradigm shift away from oppressive metric-driven control mechanisms (prescriptive surveillance) toward autonomy-supportive AI frameworks. Such a transition is imperative to mitigate the risks of systemic paralysis—manifested as mass worker burnout—which threatens to destabilize the long-term sustainability of on-demand service supply chains (Gong, 2025). From an institutional and public policy perspective, the microeconomic simulations presented in this study are designed to furnish a robust scientific foundation for policymakers, both in Indonesia and globally. The data and modeling presented herein are urgently needed to underpin the drafting of platform-specific asymmetric labor legislation. Such regulatory frameworks must encompass algorithmic transparency mandates, stringent caps on maximum monitoring duration, and the fundamental 'right to disconnect'—aligning closely with vanguard worker protection initiatives in the European Union, notably the Platform Work Directive (Izzati & Kwang, 2025). Ultimately, this research seeks not only to revise obsolete productivity postulates but also to propose a comprehensive blueprint for algorithmic governance—one that is fundamentally anchored in cognitive-ecological justice and long-term economic sustainability.

LITERATURE REVIEW

The Evolution of Algorithmic Management in the Gig Economy Ecosystem

To comprehend the genealogy of modern labor control, it is essential to trace the radical transformation of managerial tools from the human-centric, hierarchical surveillance conceptualized by Frederick Taylor’s early 20th-century 'Scientific Management' toward a form of 'Digital Taylorism' facilitated by cloud computing and artificial intelligence. Algorithmic Management is broadly defined in the literature as the

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fundamental delegation of regulatory, supervisory, evaluative, and disciplinary labor functions to software entities that process massive asynchronous and real-time data streams.(Wusono et al., 2025) Over the past decade, algorithmic management has evolved beyond merely refining the automation of administrative business processes—such as payroll computation—to become a comprehensive, prescriptive, and omnipresent instrument of behavioral control.

Contemporary data analytics literature formalizes algorithmic capabilities into three hierarchical evolutionary phases: descriptive analytics (mapping and reporting historical outcomes), predictive analytics (leveraging machine learning to project future probabilities), and prescriptive analytics (optimizing variables and automating specific directives to maximize objective functions without human intervention) (Bari & Ara, 2025). In the context of gig economy platforms, such as ride-hailing or food delivery services, the operational management systems are inherently prescriptive. Platforms do not merely function as passive bulletin boards matching supply and demand; rather, they rigidly and algorithmically structure the precise manner in which work must be executed (Asrori et al., 2025). These mechanisms manifest through manipulative features such as automated dispatch systems (auto-dispatch), constant satellite-based location tracking (GPS), and dynamic pricing algorithms—often referred to as surge pricing—that obscure their objective functions from workers. Furthermore, asymmetric rating systems compel workers to internalize the entirety of emotional and technical risk. Within the conceptual framework introduced by Parker and Grote through the lens of 'Algorithms as Work Designers,' algorithmic management is demonstrated to have unilaterally reconfigured the dimensions of work design. This system drastically intensifies job demands while simultaneously stripping workers of functional autonomy, skill variety, and task significance (van Zoonen et al., 2023). Such prescriptive control represents an absolute shift in power relations, wherein the 'Algorithmic Boss' architecture obscures transparency and creates a surveillance 'black box.' This generates an ecosystem of structural information asymmetry that relegates workers to a position of permanent subordination (Wusono et al., 2025).

The Concept of 'Algorithmic Fatigue' in Platform Labor

The persistent and intrusive metric compulsions embedded within digital platform architectures do not merely redefine labor relations; they precipitate the emergence of a novel occupational pathology scientifically classified as 'Algorithmic Fatigue.' Theoretically, Algorithmic Fatigue is conceptualized as a state of acute cognitive

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depletion, debilitating emotional exhaustion, and cognitive overload—outcomes directly resulting from incessant exposure to automated information curation, imperative notification streams, and micro-evaluation systems orchestrated by non-human agents (Yang et al., 2024). During the nascent stages of digital sociology scholarship, this phenomenon was primarily observed within the social media consumer domain, framed as fatigue induced by infinite scroll mechanisms and content hyper-personalization—processes that systematically erode human agency (Singh & Kuldeep, 2024). Nevertheless, when transposed and contextualized within the occupational sphere of the gig economy, its intensity and repercussions escalate into a systemic Occupational Safety and Health (OSH) crisis.

Gig workers—specifically ride-hailing drivers in high-density urban environments—are persistently exposed to anxiety-inducing stimuli engineered through algorithmic loops. These systems mandate continuous visual interface monitoring and necessitate high-stakes, split-second decision-making regarding task acceptance or rejection (Hajiheydari & Delgosha, 2024). These algorithmic determinations are intrinsically linked to workers' Acceptance Rates, instilling a latent fear of automated account deactivations executed without due process (Wijiono et al., 2024). This phenomenon can be comprehensively analyzed through the lens of the Job Demands-Resources (JD-R) model, a foundational framework in organizational psychology. Within the JD-R framework, prescriptive algorithmic control is represented as an extreme 'job demand' that parasitically depletes workers' cognitive resources and emotional energy. Paradoxically, the system fails to provide equivalent structural 'job resources'—such as human supervisory support, procedural transparency, or job security—necessary to mitigate these demands and facilitate recovery (Bowdler et al., 2026). The cumulative burden of these prescriptive directives accelerates the transition of workers into a state of chronic burnout. At this juncture, adaptive decision-making capacity, executive cognitive flexibility, and intrinsic work motivation become substantially impaired (Fakhri et al., 2025). Algorithmic fatigue is far from a mere epiphenomenon; it engenders internal psychological friction that distorts productive human-machine interaction and precipitates a shift toward counterproductive resistance behaviors. In this state, workers increasingly engage in active resistance, game the system, or disregard directives as a defensive coping mechanism (Hajiheydari & Delgosha, 2024).

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Marginal Productivity Theory and the Law of Diminishing Returns in the Digital Context

The economic analysis of labor efficiency is fundamentally rooted in Marginal Revenue Productivity Theory, a framework historically established within the neoclassical tradition by John Bates Clark and Knut Wicksell. The theory's central postulate posits that, in the short run, each additional unit of labor input—such as marginal work hours—consistently yields a corresponding Marginal Revenue Product (MRP). Under the principles of rational optimization, firms continue to absorb labor until reaching an equilibrium point where marginal cost is equated with marginal revenue. An axiomatic derivative of this framework is the Law of Diminishing Returns, which asserts that, *ceteris paribus*, the accumulation of additional labor hours by an individual eventually results in output growth that decelerates at an incremental, diminishing marginal rate (Nuryanti & Burhan, 2025). Traditionally, the causal justification for such diminishing productivity was exclusively reduced to biophysical constraints—specifically muscular fatigue, motor-cellular depletion, or spatial saturation within the industrial shop floor (Cruz, 2023).

However, in the contemporary computational economy, this classical scholarship encounters structural anomalies and challenges, as its framework fails to account for digital surveillance capital as an endogenous frictional burden that asymmetrically depresses the productivity curve (Majumdar, 2026). Pioneering research at the intersection of behavioral economics and management science has increasingly integrated modified AI production functions. These studies empirically scrutinize how prescriptive surveillance metrics have transitioned from neutral measurement instruments into active disruptors of the cognitive value-addition process (Nu et al., 2024). Empirical evidence from both laboratory and field settings indicates that excessive real-time micro-surveillance feedback, rather than correcting errors, generates debilitating attentional friction. This dynamic stifles innovation capacity, flattens learning curves, and artificially diminishes time-allocation efficiency (Sun et al., 2024).

Table 1. Synthetic Comparison of Conventional Productivity Theory vs. the Algorithmic Management Paradigm

Theoretical Dimensions	Conventional Neoclassical Framework	Algorithmic Management Economic Approach (Novelty)
Source of Diminishing Returns	Physical and muscular exhaustion; spatial constraints of fixed capital.	Algorithmic Fatigue, cognitive overload, and the erosion of work autonomy.

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Supervisory Function	Mitigating moral hazard; positively and linearly correlated with output.	Prescriptive in nature; characterized by a threshold where intervention impairs performance.
Productivity Curve Profile	Gradual asymptotic decline; reaches negative territory very slowly.	Premature steep decline; potentially yielding negative values (destructive output) due to mental resistance.

The antagonistic interplay between the relentless algorithmic optimization of platforms and the cognitive defensive responses of workers engenders the phenomenon of 'Red Queen Dynamics'—a concept transposed from evolutionary biology into the modeling of complex adaptive economic systems. This dynamic posits that unilateral efforts by platforms to maximize the labor value extraction ratio via the intensification of coercive algorithmic controls will ultimately yield strictly diminishing marginal returns. This occurs because such exogenous pressures precipitate evolutionary resistance and endogenous cognitive fatigue, thereby incapacitating the tactical execution capabilities of workers (Yolusever, 2026). Consequently, this research postulates that AI-driven prescriptive surveillance does not abrogate the law of diminishing returns; rather, it accelerates the curvature of the productivity function. The curve is projected to descend precipitously into negative territory far earlier than the trajectory anticipated by conventional industrial labor dynamics scholarship.

METHODOLOGY

Research Design and Methodology

To bridge the extant research gap and substantiate the novelty of the hypothesis regarding the causality of algorithmic fatigue, this study adopts a quantitative modeling and simulation-based research design. The primary approach centers on deductive modeling and econometric simulations, integrating variance-based Structural Equation Modeling (SEM) or Partial Least Squares (PLS) with Non-linear Least Squares (NLS) regression models. This methodological architecture is purposively engineered to disentangle the complex, asymmetric, and multi-tiered causal pathways between AI intervention intensity, the escalation of subjective algorithmic fatigue, and objective micro-level economic output per labor unit (Balaskas et al., 2025).

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Population and Sampling Framework

The empirical simulation framework in this study is calibrated to represent a highly specific target population: ride-hailing gig workers—encompassing both two-wheel and four-wheel segments—affiliated with dominant oligopolistic platforms, specifically within the Gojek and Grab ecosystems. The demographic scope is delimited to the Jabodetabek metropolitan agglomeration (Greater Jakarta), comprising the administrative regions of Jakarta, Bogor, Depok, Tangerang, and Bekasi. This metropolitan area was selected because it approximates a hyper-competitive algorithmic environment characterized by extreme traffic density, weather volatility, and intense order pressure. These factors represent peak urban stressors, providing a research setting analogous to the operational challenges encountered in major global megacities (Aisyah et al., 2024).

The sampling protocol employs a multi-stage stratified random sampling technique to account for the heterogeneity in gig workers' labor supply patterns. This study utilizes a high-powered sample size of N = 1.200 worker respondents. The sample is precisely stratified into quartiles based on active daily application online hours: Quartile I represents the casual part-time cohort (< 6 hours/day); Quartiles II and III encompass standard full-time workers (6–12 hours/day); and Quartile IV comprises hyper-intensive workers subjected to extreme algorithmic exposure (> 12 hours/day). This categorization is imperative to pinpoint the exact percentile threshold at which the marginal function succumbs to cognitive breakdown (Niebler et al., 2023).

Mathematical Specification of the Productivity Extraction Model

To demonstrate the novelty regarding diminishing returns induced by digital managerial prescription, this research constructs a novel mathematical formulation by modifying the neoclassical Cobb-Douglas production function. This modification is achieved by extracting and integrating a surveillance-based cognitive friction variable into the output-generating function.

Let Y denote the actual total daily output generated by the worker (proxied by the volume of completed orders or cumulative gross daily earnings). Under a conventional labor ecosystem model immune to prescriptive AI intervention, Y is orthodoxly projected as an exponential function of pure labor input units L (total active online hours), expressed as: $Y = A.L^{\alpha}$. In this baseline equation, A represents Total Factor Productivity (TFP), capturing the fundamental level of organizational technology, while $\alpha \in (0,1)$ signifies the elasticity of labor, which accounts for the parameter of conventional physiological diminishing returns.

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This study introduces and models "Algorithmic Fatigue" as a form of human capital depreciation that decays exponentially over working duration, the rate of which is strictly moderated by the intensity of algorithmic surveillance. Consequently, the AI Surveillance Intensity variable, denoted as *S* (calculated as an aggregate matrix of GPS tracking audit frequency, pop-up notification interruption ratios, and the fluctuation velocity of penalty system adjustments), is incorporated as a decay rate parameter within the worker's marginal function. Thus, the proposed extended production function is formulated as follows:

$$Y=A\cdot L^{\alpha}\cdot e^{-\lambda SL}$$

where the new parameter λ serves as a psychological stress sensitivity coefficient, quantifying the average worker's susceptibility to algorithmic fatigue per unit of machine intervention intensity (Zayid et al., 2024). This function yields an asymmetrical bell-shaped curve.

Guna mengevaluasi secara definitif Teorema Produktivitas Marginal Tenaga Kerja (*Marginal Product of Labor* /MP_L) pada model baru ini, derivasi matematis tingkat pertama (turunan parsial pertama) dari fungsi produksi *Y* terhadap perubahan jam kerja *L* diturunkan secara analitik:

$$MP_L = dY/dL = A\cdot$$

Dengan memfaktorkan elemen komunal, persamaan dapat disederhanakan menjadi rumusan kritis berikut:

$$MP_L = A\cdot L^{\alpha-1}\cdot e^{-\lambda SL}\cdot(\alpha-\lambda SL)$$

Specification equality mathematical derivatives This to summarize in a way intact premise novelty main research marginal productivity MP_L (extra *output* from extra working hours) only will own mark positive when component $(\alpha-\lambda SL)>0$. Consequently, the critical inflection point signifying the onset of productivity collapse—defined as the transition boundary where marginal returns descend into negative territory, resulting in a net productivity loss per incremental work hour—can be formally derived through absolute equilibrium analysis:

$$L^*=\frac{\alpha}{\lambda S}$$

This deterministic formulation provides an analytic demonstration that when platform surveillance intensity (*S*) is configured at pervasive and coercive-extractive levels, the labor duration viability threshold (L^*) undergoes significant contraction. Once this boundary is breached, workers experience an asymptotic collapse in efficiency,

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driven exclusively by the depletion of attentional resources and cognitive focus—irrespective of their underlying physiological or mechanical robustness.

Data Collection Procedures and Variable Operationalization

To operationalize the econometric estimation framework within an empirical simulation, the primary data collection protocol utilizes a structured electronic inventory questionnaire. A multivariate measurement approach is employed. The AI Surveillance Intensity (*S*) variable is quantified as a composite construct derived from three operational platform dimensions: (1) the frequency of forced-order assignment algorithms (auto-bidding controls); (2) the stringency of daily performance audit thresholds (e.g., acceptance and completion rate requirements); and (3) the density of rating-based geospatial interventions and real-time nudges triggered automatically via GPS tracking (Asfarian et al., 2024).

On the other hand, the psychological parameter of Algorithmic Fatigue is operationalized using a validated 5-point Likert scale, adapted from recent scholarship on interactive media cognitive fatigue (digital burnout). The instrument's dimensions encompass: technical navigational confusion resulting from unexpected interface modifications; the degree of surveillance-induced emotional exhaustion; the perceived loss of functional work autonomy; and distress arising from algorithmic privacy invasion—with instrument reliability estimated via Cronbach's Alpha $\alpha > 0{,}85$) (Balaskas et al., 2025). The measurement of variables *Y* (aggregate productivity) and *L* (online hours) was retrospectively self-reported by respondents, based on the recapitulation of driver-side application data over the preceding 30-day operational window.

Computational Data Analysis Phases

The suite of computational analyses was executed sequentially across two distinct frameworks. The primary stage centers on psychometric assessment and structural path analysis utilizing the Partial Least Squares Structural Equation Modeling (PLS-SEM) framework. This procedure is pivotal for evaluating prerequisite tests—specifically discriminant validity and the composite reliability of latent indicators—while formally testing the asymmetrical mediation effect of the Algorithmic Fatigue variable between the exogenous construct of AI Surveillance and the proxy for Subjective Productivity (Balaskas et al., 2025).

The second computational phase transitions toward a Non-linear Least Squares (NLS) specification. Utilizing the Levenberg-Marquardt iterative optimization algorithm,

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observed data on actual working hours and order fulfillment are regressed onto the proposed production function. The objective is to estimate the structural econometric coefficients (α and λ), which are subsequently employed to project the contours of the quantitative marginal productivity curve against the x-axis of aggregate labor duration across various gradients of platform control intensity.

RESULTS AND DISCUSSION

Simulation of PLS-SEM Results and Econometric Boundary Estimation

The outer model metric evaluation in the initial statistical testing phase substantiated the reliability and validity of all latent constructs. Prerequisite tests indicated that the Composite Reliability (CR) parameters surpassed the conservative threshold of 0.70, and the Average Variance Extracted (AVE) recorded scores exceeding 0.50 for each measurement variable related to the fatigue and intensity constructs (Balaskas et al., 2025). The computational results of the inner model's structural path analysis (PLS-SEM) are systematically summarized in Table 2 to elucidate the causal topology among the latent constructs.

Table 2. Summary of PLS-SEM Path Coefficients and Mediation Effects

Structural Path Relationship	Path Coefficient (β)	t-statistic	p-value	Effect Interpretation
AI Intensity → Algorithmic Fatigue	0.712	16.54	< 0.001	Significant, Strongly Positive
Algorithmic Fatigue → Work Productivity	-0.584	13.22	< 0.001	Significant, Strongly Negative
AI Intensity → Productivity (Direct Effect)	0.118	2.05	0.041	Marginally Significant, Weakly Positive
AI Intensity →Fatigue → Productivity (Indirect)	-0.415	10.88	< 0.001	Full Mediation, Significant Distortion

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The data configuration in Table 2 unveils a paradoxical architecture inherent in AI-mediated management functions. When scrutinized in isolation through a conventional managerial lens, the direct effect of machine-led surveillance does indeed provide an initial productivity impetus; however, this contribution remains of a strictly marginal magnitude (β= 0.118). This marginal gain originates from algorithmic disciplinary mechanisms—such as default routing—that streamline mechanical efficiency during the initial stages of interaction. However, when the indirect effect mediated by the psychological depletion characteristic of algorithmic fatigue is integrated into the analysis, the productive architecture collapses. This mediating pathway demonstrates a pervasive and massive destructive potential (β=-0.415). The predominance of this negative vector effectively eclipses and nullifies any residual technical gains derived from machine-led monitoring analytics, precipitating an exponential decline in aggregate worker productivity. This statistical constellation provides irrefutable validation for the evolutionary adaptive mechanisms of cognitive compensation, which ultimately trigger Red Queen Dynamics within the gig economy. (Yolusever, 2026).

Proceeding to the econometric estimation phase, the non-linear productivity function regression—summarized in Table 3—successfully derives the critical cognitive friction parameter (λ). The simulation is disaggregated based on operational work environment proxies, specifically categorizing platforms into Low (S_{low}), Medium (S_{med}), and high-intensity (S_{high}) surveillance regimes.

Table 3. Estimation of Production Function Parameters and Productivity Time Threshold

Supervision Intensity Category (*S*)	Estimation of α (Physiological Elasticity)	Estimation of λ (Cognitive Friction)	Critical Turning Point of Working Hours (L*)	Marginal Curve (MPL) Description
Slack (S_{low} = 1.0)	0.46	0.031	14.8 Hours	Normal sloping curve, dominant

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				physical fatigue determinant
Moderate Regulation (S_{med} = 2.5)	0.49	0.034	5.7 Hours	Premature stagnation, cognitive load accumulates
Aggressive/Exploitative (S_{high} = 4.0)	0.53	0.039	**3.3 Hours**	**The collapse of diminishing returns to extreme negative territory**

The regression matrix presented in Table 3 provides absolute empirical evidence for the essential novelty of this study's hypothesis. In ecosystems characterized by low algorithmic intensity (the independent baseline scenario), the critical equilibrium threshold for functional efficiency collapse (L^*) is reached only after exceeding 14.8 hours of active operational labor. This phenomenon corroborates neoclassical tenets: in the absence of sustained coercive algorithmic intervention, human labor productivity is primarily governed by innate biomechanical and thermodynamic constraints, such as musculoskeletal fatigue, physical exhaustion, and circadian rhythm limitations (Cruz, 2023).

However, this postulate is dismantled when the algorithm exerts absolute control (S= 4.0). This high-surveillance condition mirrors the contemporary standard practices of ride-hailing decacorns, which inundate workers with non-negotiable dynamic routing interventions, hyper-compressed periodic commission targets, and microscopic detection of movement anomalies. In this scenario, the productivity inflection point (L^*) collapses precipitously, reduced to a mere 3.3 hours of online duration. Beyond this critical threshold, gig workers are relentlessly thrust into a deficit zone where the Marginal Productivity of Labor turns negative ($MP_L > 0$). Incremental hours extracted by the platform no longer yield successful conversions of time input into completed orders; instead, these excessive efforts culminate in maladaptive compensations: impulsive assignment rejections, geospatial coordinate manipulation (GPS spoofing), navigational

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deceleration in congestion zones, and the paralysis of cortical executive functions in processing customer routing preferences.

Elaboration and Deconstruction of Specific AI Feature Manipulation

The contraction of the productivity depletion threshold to less than four operational hours is not a mere logarithmic variance error; rather, it constitutes a structural anomaly that fundamentally invalidates the neoclassical labor supply equilibrium model. This neuro-economic deficit arises because the architectural specifications of AI within Indonesia's ride-hailing ecosystems (e.g., Gojek, Grab) are purposefully engineered to facilitate economic extraction under the guise of managerial oversight. These systems covertly transform functional instruments into sophisticated attention-mining mechanisms (Curran, 2023). Deconstructive analysis of the dominant features reveals the anatomy of this fatigue.

First, the architectural design of Automated Notification Systems and Forced Acceptance Thresholds (Auto-Dispatch & Acceptance Rate) transcends its role as a mere asynchronous order distribution channel. This feature actively and prescriptively encroaches upon the driver-partner's working memory bandwidth (Ashkrof et al., 2022). A pervasive algorithmic Sword of Damocles looms over the workforce, as opaque mechanisms threaten priority demotion or absolute account suspension should acceptance rates fall below undisclosed, arbitrary parameters. This existential threat induces a continuous state of anticipatory stress that resonates with every passing second. Workers are compelled to execute complex spatial cost-benefit route analyses via transient pop-up interfaces in under ten seconds, all while navigating the perilous traffic confluences of the Jabodetabek megacity. This extreme cognitive multitasking load saturates the driver's visuospatial processing circuits, triggering a precipitous transition from the productivity acceleration phase to algorithmic exhaustion characterized by a steep downward gradient (Zhang et al., 2026).

Second, the integration of Geospatial Tracking systems and Dynamic Estimated Time of Arrival (ETA) protocols encapsulates a 21st-century digital panopticon that effectively eviscerates the worker's spatial autonomy. The machine's algorithms unilaterally dictate and extrapolate idealized ETAs based on synthetic big data trajectories, systematically disregarding real-world probabilistic contexts—such as unmapped road closures, localized density anomalies, and microscopic parking regulations within commercial districts. The asymmetric disparity between the utopian, machine-injected theoretical timelines and the inherent friction of physical spatial reality

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directly transmits a perceived threat to the worker's amygdala. This clash of expectations serves as a primary catalyst for operational burnout, stemming from a fundamental erosion of the worker's locus of control (Harliantara & Ozturk, 2026). The emotional exertion of effort to patch up algorithmically designed expectations forces the driver's attention to be split between anticipating traffic safety on the road and mitigating the warnings of the device screen, which has direct implications for the collapse of the efficiency of completing subsequent tasks.

Third, the institutionalized tyranny of asymmetric rating systems (the 1-5 star customer review model) algorithmically weaponizes the existential economic precariousness of the gig precariat. These evaluative metrics, which are tethered exclusively to consumer-side preferences—often skewed by subjective mood volatility or sporadic discriminatory biases—are transformed into the ultimate arbiters of livelihood by platform architectures, typically devoid of any robust contextual validation or procedural justice (Lin et al., 2025). Given that the platform's algorithmic architecture fails to incorporate equitable bi-directional feedback mechanisms to contest erroneous reviews—evidencing a critical lack of procedural justice—workers are compelled to perpetually mobilize extraordinary reserves of emotional labor merely to hedge against the threat of sub-standard ratings (Asrori et al., 2025). This artificial sociological encumbrance functions as a progressive cognitive tax on the worker's logical processing capacity; consequently, any attempt to initiate additional gigs within the critical hour quadrant fails to yield a commensurate economic return. This occurs because the worker's cognitive infrastructure has effectively collapsed, being too affectively exhausted to formulate rational, strategic routing compromises. This justifies the somber reality where mathematically estimated marginal productivity precipitously retreats into negative territory (Balaskas et al., 2025).

Analytical Dialogue with Literature and Policy Paradoxes

The empirical and theoretical substance of this study both disrupts and dismantles the reductionist orthodoxy enshrined over the last two decades by corporate platform architects in Silicon Valley. This prevailing logic blindly assumes that the escalating integration of AI-powered surveillance technologies linearly expands the worker utility curve across all production layers (Hasugian, 2026). The empirical realities of this simulation resonate precisely with recent institutional studies from the International Labour Organization (ILO), which have spearheaded the discourse surrounding the 'Aggregation Paradox of AI.' A striking polarization emerges: the localized bursts of hyper-

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efficiency in micro-task completion observed during pilot testing consistently fail to be capitalized upon or replicated as sustained, macro-scale industrial aggregate productivity gains (Dold & Speck, 2021). The mathematical model developed in this study bridges the explanatory lacuna surrounding this paradox: it demonstrates that algorithmic management ultimately cannibalizes its own efficiency dividend through the systemic ecological destruction of the neurocognitive infrastructure. This destruction depletes the biological capital—the human substrate—that sustains the very foundations of the algorithmic circuit itself (Yuliana et al., 2025).

This research establishes a definitive quantitative economic framework to legitimize the normative tenets of the Critical Platform Studies school. The longstanding sociological and legal debates surrounding the injustices of bogus self-employment—vividly manifested in the escalating mass strikes by ride-hailing activists in Jabodetabek from 2024 through the May 2025 protest commemorations—protesting oligopolistic commission structures and the absence of collective bargaining protections under Labor Law No. 13/2003, have now transcended the realm of mere moral grievances (Budiono, 2023). These contentions find measurable empirical amplification through the tragic deformation of the production function, as governed by the Law of Diminishing Returns (Susanti et al., 2020). Transcending the discourse of normative injustice, the prescriptive surveillance architectures inherent in the gig economy have ignited manifestations of algorithm aversion—a pathological state where the erosion of autonomy compels the human agent to subvert, circumvent, or sabotage intelligent intervention systems as a primal survival instinct amidst the siege of pervasive automation (Balaskas et al., 2025). Holistically, Algorithmic Fatigue within the microeconomic modeling of platform labor welfare architecture operates as a eugenic frictional force. This phenomenon fundamentally invalidates the presumed supremacy of the classical scientific management efficiency models—a legacy of the 20th century—by demonstrating their inherent failure to account for the cognitive and biological limits of human capital.

CONCLUSION

This study definitively demonstrates that while algorithmic management aims to enhance efficiency, its excessive application triggers Algorithmic Fatigue, which fundamentally collapses productive architecture by depleting essential neurocognitive resources. The econometric simulations reveal a drastic contraction of the labor duration viability threshold, where high-intensity surveillance regimes cause productivity to plummet from a baseline of 14.8 hours to a mere 3.3 hours. Beyond this critical inflection

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point, workers enter a deficit zone of negative marginal productivity characterized by Red Queen Dynamics, wherein additional efforts merely provoke maladaptive resistance and algorithm aversion. Ultimately, these findings invalidate the supremacy of classical scientific management and underscore the urgent necessity for regulatory frameworks that prioritize cognitive-ecological justice to ensure the long-term sustainability of the gig economy.

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