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FACTORS SHAPING JOB SATISFACTION AMONG LOCAL MACHINE OPERATORS IN MALAYSIA'S MECHANISED OIL PALM ESTATES

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ABSTRACT

Previous studies on mechanised oil palm plantations have primarily focused on labour productivity, technology adoption and operational performance, with limited attention given to understanding the factors shaping job satisfaction among local machine operators who are central to mechanised field operations. Addressing this gap, this study examined the influence of plantation mechanisation, intrinsic factors, and extrinsic factors on job satisfaction among local machine operators in Malaysia's mechanised oil palm estates. Data were collected from 418 local machine operators and analysed using partial least squares structural equation modelling (PLS-SEM). The results indicate that plantation mechanisation and extrinsic factors exert significant positive effects on job satisfaction, whereas intrinsic factors do not demonstrate a significant influence. Extrinsic factors emerged as the strongest predictor of job satisfaction, followed by plantation mechanisation. The structural model explained 37.2% of the variance in job satisfaction. The findings support the relevance of the Technology Acceptance Model (TAM) and Herzberg's Two-Factor Theory in explaining job satisfaction within mechanised plantation environments. The study highlights the importance of favourable employment conditions and positive technological experiences in shaping workforce evaluations and provides practical insights to strengthen workforce satisfaction in mechanised plantation operations. The findings further suggest that technological experiences constitute an important dimension of employees' overall work evaluations within machine-dependent plantation environments.

Keywords: job satisfaction, local machine operators, mechanisation, oil palm estates, working conditions.

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INTRODUCTION

Mechanisation has become a defining feature of oil palm field operations in Malaysia as plantation organisations respond to persistent labour shortages, declining interest among younger workers, and an ageing workforce (Crowley, 2020; Ismail et al., 2024; Shahiri & Du, 2025; Thaddeus et al., 2023). National initiatives under the Twelfth Malaysia Plan have further encouraged the adoption of machinery for activities such as spraying, manuring, harvesting support and fresh fruit bunch (FFB) transportation, positioning mechanisation as a practical strategy for addressing labour constraints while improving operational efficiency (Economic Planning Unit, 2021). Similar developments are evident globally, where agricultural mechanisation is increasingly recognised as an important approach for sustaining productivity under constrained workforce conditions (Daum, 2023; Zapata-Hernández et al., 2024).

Beyond improving operational efficiency, mechanisation fundamentally reshapes the nature of plantation work. Mechanised field operations require operators to perform specialised tasks, comply with structured operating procedures and coordinate closely with field teams, representing

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a substantial departure from conventional manual plantation practices (Baur & Iles, 2023). Consequently, the effectiveness of mechanisation depends not only on machine capability but also on operators' acceptance of technology, their adaptation to machine-assisted work and the organisational conditions that support its effective implementation. Previous studies have shown that equipment unreliability, delayed maintenance and inadequate operational coordination can disrupt work routines, reduce operational efficiency and negatively influence employees' work experiences, thereby limiting the intended benefits of mechanisation (Hobbs et al., 2020; Nafea et al., 2025; Thaddeus et al., 2023).

As mechanisation becomes increasingly embedded within plantation operations, understanding employees' work experiences has become equally important. Job satisfaction is widely recognised as an important indicator of workforce stability because it reflects employees' overall evaluation of their work environment and influences their willingness to remain in their organisations (Davidescu et al., 2020; Fletcher et al., 2018). Nevertheless, previous studies on mechanised oil palm plantations have predominantly focused on labour productivity, technology adoption and operational performance, with comparatively limited attention given to understanding the factors shaping job satisfaction among local machine operators. Moreover, although studies on job satisfaction acknowledge the importance of employment conditions, studies conducted within mechanised plantation settings have generally examined technological and organisational dimensions separately. Consequently, limited evidence is available on how technological perceptions and employment conditions jointly shape job satisfaction among local machine operators in mechanised plantation environments (Ismail et al., 2024; Mohiddin et al., 2021; Ramli et al., 2023; Thaddeus et al., 2023; Zulkefli et al., 2020).

To address this gap, the present study examines the factors shaping job satisfaction among local machine operators in Malaysia's mechanised oil palm estates using an integrated analytical framework that combines the Technology Acceptance Model (TAM) and Herzberg's Two-Factor Theory. TAM explains technology-related evaluations through perceived usefulness and perceived ease of use (Davis, 1989; Davis et al., 1989), whereas Herzberg's Two-Factor Theory distinguishes intrinsic factors, including achievement, growth, and recognition, from extrinsic factors such as working conditions, job security, and salary (Herzberg et al., 1959). Although both theories have been widely applied in their respective domains, they explain different aspects of employees' work experiences. TAM focuses on employees' evaluations of technology, whereas Herzberg's framework explains how employment conditions influence job satisfaction. Neither theory independently captures the combined influence of technological perceptions and employment conditions that characterise machine-dependent plantation work.

By integrating these complementary theoretical perspectives, this study provides a more comprehensive explanation of job satisfaction within mechanised plantation environments. Unlike previous studies, which have largely examined technological and organisational dimensions independently, the present study explains how technological perceptions and employment conditions jointly shape job satisfaction within a single analytical framework. In doing so, the study extends existing plantation research beyond labour productivity, technology adoption, and operational performance by demonstrating that operators' evaluations of technology constitute an important component of overall work evaluation alongside employment conditions. The study also contributes empirical evidence from Malaysia's mechanised oil palm estates, a context that remains underrepresented in the literature despite the industry's increasing reliance on mechanised field operations.

Within mechanised plantation operations, reliable machinery and positive technological experiences are expected to contribute to more favourable evaluations of work. Accordingly, plantation mechanisation is hypothesised to have a significant positive effect on job satisfaction (H1). Similarly, opportunities for achievement, growth, and recognition are expected to enhance operators' perceptions of their work, leading to the hypothesis that intrinsic factors positively influence job satisfaction (H2). Finally, favourable employment conditions, including supportive working environments, job security, and adequate remuneration, are expected to strengthen perceptions of organisational support and improve employees' overall work evaluations. Accordingly, extrinsic factors are hypothesised to have a significant positive effect on job satisfaction (H3).

Figure 1 presents the conceptual framework guiding the study and illustrates the proposed relationships among plantation mechanisation, intrinsic factors, extrinsic factors and job satisfaction.

MATERIALS AND METHODS

This study adopted a quantitative cross-sectional survey design to examine factors associated with job satisfaction among local machine operators in mechanised oil palm estates in Malaysia. The survey approach captured operators' perceptions of

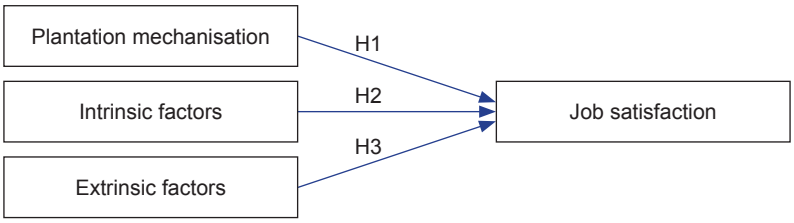

Figure 1. Conceptual framework of the study.

mechanisation, intrinsic work factors and extrinsic work conditions at a single point in time, enabling systematic assessment of relationships between the study variables within the operational context of mechanised plantation work.

Study Population and Location

The study population comprised local machine operators engaged in core mechanised field tasks, including spraying, manuring, harvesting support and FFB transportation. Estates representing a range of operational sizes and terrain characteristics were included to capture variation in mechanised deployment and field operating conditions across Malaysia.

Sampling Strategy

Sampling followed the estate-class categories established by the Malaysian Palm Oil Association (MPOA), whereby estates are classified according to operational size. A proportionate stratified sampling approach was employed to ensure proportional representation of estates across the different MPOA classifications. Eligible respondents comprised local machine operators directly involved in mechanised field operations who satisfied the predefined inclusion criteria. Through coordination with estate management, all eligible operators within each participating estate were invited to complete the survey.

This sampling strategy was designed to obtain broad coverage of local machine operators across estates with different operational sizes and mechanisation characteristics while maintaining proportional representation across the predefined estate strata. Such an approach is appropriate for heterogeneous populations because it improves the distribution of respondents across relevant subgroups and reduces the potential for disproportionate representation of any single estate category (Sekaran & Bougie, 2016). By including respondents from estates representing different MPOA classifications and diverse operational contexts, the study captured variation in mechanised plantation settings relevant to the research objectives. Although the absence of a comprehensive national sampling frame precluded statistical generalisation to all local machine operators in Malaysia, the sampling strategy was appropriate for examining the hypothesised relationships among the study constructs within the participating mechanised oil palm estates. Survey links were distributed during morning briefings and through internal communication channels.

Instrumentation

The questionnaire measured four constructs using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Likert-type scales are well suited to capturing attitudinal and perceptual responses and are widely applied in field-based and organisational studies (Likert, 1932). The five-point scale aligns with methodological guidance for structural equation modelling using partial least squares structural equation modelling (PLS-SEM), balancing response variability with respondent ease in field survey settings (Hair et al., 2019). Measurement items were adapted from multiple previously validated instruments to ensure alignment with the study constructs and theoretical foundations. Relevant items were selected and contextually refined to reflect the operational characteristics of mechanised oil palm plantation work in Malaysia while preserving the original theoretical meaning of the measures. The adapted questionnaire subsequently underwent content validation by four subject-matter specialists, comprising two academics with expertise in research methodology and organisational behaviour and two senior plantation practitioners with experience in mechanisation and plantation operations. Feedback from the expert review was incorporated to improve item clarity, relevance and contextual appropriateness prior to pilot testing. *Table 1* summarises the constructs, dimensions and measurement sources.

A pilot test involving 38 local machine operators confirmed item clarity and demonstrated acceptable internal consistency, with Cronbach's alpha values ranging from 0.78 to 0.90, exceeding commonly accepted reliability thresholds (Nunnally & Bernstein, 1994). Feedback obtained during the pilot study, together with the preliminary reliability

TABLE 1. SUMMARY OF CONSTRUCTS AND MEASUREMENT SOURCES

Construct	Dimensions	Items	Key sources
Plantation mechanisation	Usefulness, ease of use	10	Davis (1989)
Intrinsic factors	Achievement, growth, recognition	6	Herzberg et al. (1959)
Extrinsic factors	Working conditions, job security, salary	13	Herzberg et al. (1959)
Job satisfaction	Job fulfilment, attitudinal inclination to stay, affective attachment to work	8	Weiss et al. (1967); Kamaruddin et al. (2018)

assessment, was used to refine the questionnaire prior to the main survey. Minor revisions were made to improve item wording, questionnaire presentation and administration procedures without altering the conceptual meaning or measurement intent of the original measurement items.

Data Collection

Data were collected between August and October 2025 using an online Google Form distributed through estate management communication channels. Estate management facilitated the dissemination of the survey link to eligible local machine operators via internal communication platforms, including WhatsApp and Telegram, to maximise coverage across estates and estate categories. As no comprehensive sampling frame of local machine operators was available and the survey link was disseminated through estate-level coordination rather than to a predefined list of identifiable individuals, a conventional response rate could not be calculated. A total of 423 completed questionnaires were received, of which 418 were retained for analysis following data screening.

Participation was voluntary. Before accessing the questionnaire, respondents were provided with a participant information statement outlining the study objectives, the voluntary nature of participation, the confidentiality of their responses, and their right to withdraw at any time without penalty. Electronic informed consent was obtained before respondents proceeded with the survey, and responses were completed outside active field working hours to minimise disruption to operational activities.

To minimise the potential for common method bias, several procedural controls were implemented during questionnaire design and data collection. Participation was voluntary and respondent anonymity and confidentiality were assured to reduce potential evaluation apprehension. Participants were informed that there were no right or wrong answers and were encouraged to provide honest responses. In addition, the questionnaire employed measurement items adapted from previously validated instruments and was administered using standardised procedures across all participating estates to ensure consistency throughout the data collection process.

Although the online survey enabled data collection across geographically dispersed estates, the possibility of self-selection bias cannot be entirely excluded because participation depended on respondents' willingness to complete the questionnaire. Nevertheless, measures were implemented to minimise duplicate submissions and maintain the integrity of the dataset throughout the data collection process. Ethical approval was obtained from the Universiti Teknologi MARA Research Ethics Committee (REC/07/2025 (PG/MR/397), 22 July 2025) and all data handling procedures complied with the Malaysian Personal Data Protection Act 2010.

Data Analysis

Data screening was conducted using the Statistical Package for the Social Sciences (SPSS) and Jamovi, while PLS-SEM analyses were performed using SmartPLS 4. PLS-SEM was selected because the primary objective of this study was to examine the predictive relationships among multiple latent constructs within an integrated analytical framework rather than to evaluate overall model fit. The approach is appropriate for analysing complex structural models comprising multiple interrelated constructs and has been widely recommended for prediction-oriented research in the behavioural and social sciences (Hair et al., 2019).

Additional data screening procedures included the assessment of data normality, potential common method bias and detection of outliers. Normality was examined through skewness and kurtosis values. Potential common method bias was assessed using Harman's single-factor test based on an unrotated principal component analysis (Podsakoff et al., 2003). The first factor accounted for 38.636% of the total variance, which is below the commonly accepted threshold of 50.000%, indicating that common method bias was unlikely to pose a serious concern in this study. Outliers were identified using a two-

stage screening procedure based on standardised latent construct scores generated in SmartPLS. Cases with standardised *z*-scores exceeding ±3.29 were flagged as potential outliers following the guideline of Tabachnick and Fidell (2019). Potential outliers were subsequently reviewed and cases exhibiting consistently extreme response patterns were removed. Latent construct scores were then recalculated, and a second-stage assessment confirmed that no additional cases exceeded the adopted threshold. A total of five observations were removed through this iterative procedure, resulting in a final dataset of 418 valid responses. The results indicated no severe deviations from normality and the screened dataset was subsequently analysed using PLS-SEM. Composite job satisfaction scores were classified into five ordinal levels (Very Low to Very High) using the proportional-interval method for descriptive interpretation (Boone & Boone, 2012; Joshi et al., 2015).

PLS-SEM analysis was conducted following a two-stage approach. In the first stage, the measurement model was evaluated by examining indicator reliability, internal consistency reliability, convergent validity and discriminant validity. Indicator reliability was assessed using outer loadings, while internal consistency was evaluated through Cronbach's alpha and composite reliability (CR). Convergent validity was examined using average variance extracted (AVE) and discriminant validity was assessed using the Heterotrait-Monotrait ratio (HTMT) and the Fornell-Larcker criterion. Variance inflation factors were also examined to assess potential multicollinearity.

In the second stage, the structural model was evaluated to examine the hypothesised relationships among the constructs. Structural relationships were estimated through bootstrapping with 10,000 subsamples, with *t*-values and *p*-values used to determine the significance of path coefficients. Model explanatory power was assessed using R^2 values, and effect sizes (f^2) were examined to determine the relative contribution of each predictor. This procedure enabled a systematic assessment of both the measurement quality and the structural relationships within the model. The final structural assessment was conducted using the revised measurement model specification.

RESULTS AND DISCUSSION

Respondent Profile

A total of 418 local machine operators participated in the study. The respondent profile indicates that the workforce was predominantly young, male and permanently employed. More than three-quarters of the respondents were aged between 20 and 35 years, while male operators accounted for 95.7% of the sample. Malays represented the largest ethnic group, followed by Indigenous respondents from Sabah and Sarawak.

The respondents generally possessed practical and technical educational backgrounds, with vocational or technical qualifications representing the largest educational category. Most respondents reported monthly earnings between RM2,001 and RM2,500 and had between one and five years of work experience. Permanent employees accounted for the majority of the sample, reflecting the operational dependence of mechanised plantation activities on a stable workforce.

Fertiliser application and spraying machinery operators constituted the largest occupational groups, indicating that mechanisation is most extensively deployed within these field operations. Training exposure was generally concentrated at the basic and intermediate levels, suggesting that most operators possessed at least foundational competency in mechanised field tasks. Collectively, these characteristics indicate that the sample comprised local machine operators with diverse demographic, employment and operational backgrounds across different estate categories. These characteristics provide contextual insight into the respondents included in the study. *Table 2* summarises the demographic characteristics of the respondents.

Descriptive Statistics for Study Constructs

Descriptive statistics for all study constructs are presented in *Table 3*. Plantation mechanisation recorded generally favourable evaluations, particularly for perceived usefulness and ease of use, indicating positive perceptions of machine-assisted work. Intrinsic factors also demonstrated relatively high mean scores, reflecting favourable perceptions of achievement, growth and recognition among machine operators.

In contrast, greater variability was observed for extrinsic factors and job satisfaction. Lower scores associated with equipment reliability, salary fairness and emotional attachment suggest that perceptions of operational support and employment conditions were less consistently positive across respondents. These findings indicate that while operators generally recognised the functional benefits of mechanisation, evaluations of work conditions and overall job satisfaction remained more varied.

The descriptive results provide an initial indication that positive perceptions of mechanisation do not necessarily correspond to uniformly high levels of job satisfaction. These patterns provide an important basis for interpreting the subsequent structural model results.

TABLE 2. DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Code	Variable/Categories	Frequency (n)	Percentage (%)
G1	**Age group (years)**		
	20–25	112	26.79
	26–30	129	30.86
	31–35	87	20.81
	36–40	47	11.24
	41–45	29	6.94
	46–50	7	1.67
	51–55	5	1.20
	56–60	2	0.48
G2	**Gender**		
	Male	400	95.69
	Female	18	4.31
G3	**Ethnicity**		
	Malay	320	76.56
	Indian	13	3.11
	Chinese	12	2.87
	Sabah indigenous	30	7.18
	Sarawak indigenous	24	5.74
	Others	19	4.54
G4	**Highest education level**		
	Lower secondary	8	1.91
	SPM/O-Level	112	26.80
	Vocational/Technical	195	46.65
	STPM/Matriculation	12	2.87
	Diploma/Advanced Diploma	77	18.42
	Bachelor's Degree	14	3.35
G5	**Monthly income (RM)**		
	1,501–2,000	75	17.94
	2,001–2,500	230	54.98
	2,501–3,000	73	17.46
	3,001–3,500	24	5.74
	3,501–4,000	11	2.63
	4,001–4,500	3	0.72
	4,501 and above	2	0.48
G6	**Work experience (years)**		
	1–5	363	86.84
	6–10	33	7.89
	11–15	12	2.87
	16 and above	10	2.39
G7	**Current role**		
	Fertiliser machinery operator	181	43.30
	Spraying machinery operator	153	36.60
	Other field roles	64	15.31
	Technical/supervisory	20	4.78
G8	**Employment type**		
	Permanent	395	94.50
	Contract	23	5.50
G9	**Training level**		
	No formal training	5	1.20
	Basic	116	27.75
	Intermediate	153	36.60
	Advanced	108	25.84
	Expert	36	8.61

TABLE 3. DESCRIPTIVE STATISTICS FOR STUDY CONSTRUCTS

Construct	Mean range	SD range	Key interpretation
Plantation mechanisation	2.80–4.07	0.74–1.21	High usefulness; reliability concerns remain
Intrinsic factors	3.83–4.37	0.69–0.85	Favourable perceptions of achievement, growth and recognition
Extrinsic factors	2.89–4.09	0.79–1.54	Mixed perceptions of work conditions and rewards
Job satisfaction	2.61–4.05	0.71–1.46	Moderate fulfilment; weaker emotional attachment

Job Satisfaction Levels

Job satisfaction scores were grouped into five proportional-interval categories to illustrate their distribution across respondents (*Table 4*). The largest proportion of respondents was concentrated within the low (40.4%) and moderate (20.3%) satisfaction categories, while fewer respondents reported high (17.7%) or very high (14.4%) levels of job satisfaction. Only 7.2% of respondents were classified within the very low category.

Overall, the results indicate that most local machine operators reported low to moderate levels of job satisfaction despite the increasing use of mechanisation. This pattern suggests that technological improvements alone may be insufficient to generate high levels of job satisfaction and supports previous findings that favourable organisational conditions remain important in shaping positive work evaluations (Spector, 1997).

Measurement Model Assessment

The reflective measurement model was evaluated at the second-order level to represent the hierarchical structure of plantation mechanisation, intrinsic factors, extrinsic factors and job satisfaction. Convergent validity and discriminant validity were examined to establish measurement adequacy prior to structural model evaluation. Following model re-specification undertaken to address the reviewer's discriminant validity concerns, the measurement model was re-estimated and reassessed to confirm the reliability and validity of the retained construct measures.

Convergent Validity

Convergent validity was assessed using outer loadings, Cronbach's alpha, CR and AVE, as presented in *Table 5*. To facilitate transparent evaluation of the hierarchical measurement model, indicator loadings for the first-order dimensions are reported alongside the reliability and validity statistics of the corresponding second-order constructs.

Several model refinements were undertaken to improve measurement adequacy while preserving theoretical coherence and construct content validity. Indicators with inadequate loading values (A5, A7, A8, C2 and C9) were removed based on statistical and conceptual considerations. Following reassessment of the measurement model, the psychological needs construct was excluded from the final model specification due to persistent discriminant validity concerns identified between psychological needs and extrinsic factors. Although construct combination was considered, the two constructs originated from different theoretical foundations and represented conceptually distinct domains. Combining them would have reduced theoretical clarity and weakened construct interpretability. The revised model was subsequently re-estimated and reassessed to confirm the adequacy of the retained measurement structure.

Several retained indicators exhibited loading values below the recommended threshold of 0.70, namely A4, A9, C1, C4, E1 and E4. Nevertheless, these indicators were retained because their removal did not result in meaningful improvements in CR or AVE. In addition, they represented conceptually important aspects of their respective dimensions and contributed to the content validity of the higher-order constructs. Retaining these indicators therefore ensured adequate construct coverage while preserving theoretically relevant content.

Cronbach's alpha values ranged from 0.766 to 0.930, CR values ranged from 0.865 to 0.954, and AVE values ranged from 0.681 to 0.878. All retained constructs exceeded the recommended thresholds for internal consistency reliability and convergent validity. Although several indicators demonstrated loadings below the preferred threshold, the overall reliability and validity statistics remained well above acceptable levels, supporting the adequacy of the retained measurement model.

Collectively, the results provide adequate evidence of convergent validity and internal consistency reliability for all retained constructs. The measurement model was therefore considered suitable for subsequent structural model evaluation.

TABLE 4. JOB SATISFACTION LEVELS

Category	Score range	Frequency	Percentage (%)
Very high	33.60–40.00	60	14.4
High	28.40–33.59	74	17.7
Moderate	23.20–28.39	85	20.3
Low	18.00–23.19	169	40.4
Very low	8.00–17.99	30	7.2
Total		**418**	**100.0**

TABLE 5. OUTER LOADINGS, CONVERGENT VALIDITY AND RELIABILITY

Construct	Item	Loading	Cronbach's alpha	CR	AVE
Plantation mechanisation (Usefulness)	A1	0.849	0.811	0.913	0.838
	A2	0.825			
	A3	0.745			
	A4	0.681			
	A6	0.759			
Plantation mechanisation (Ease of use)	A9	0.650			
	A10	0.917			
Intrinsic factors (Achievement)	B1	0.910	0.861	0.911	0.781
	B2	0.907			
Intrinsic factors (Growth)	B3	0.903			
	B4	0.908			
Intrinsic factors (Recognition)	B5	0.924			
	B6	0.923			
Extrinsic factors (Working conditions)	C1	0.657	0.766	0.865	0.681
	C3	0.815			
	C4	0.655			
	C5	0.806			
	C6	0.771			
	C7	0.800			
	C8	0.843			
Extrinsic factors (Job security)	C10	0.921			
	C11	0.936			
Extrinsic factors (Salary)	C12	0.954			
	C13	0.952			
Job satisfaction (Fulfilment)	E1	0.602	0.930	0.954	0.878
	E2	0.809			
	E3	0.701			
Job satisfaction (Attitudinal inclination to stay)	E4	0.561			
	E5	0.966			
	E6	0.961			
Job satisfaction (Emotional attachment)	E7	0.967			
	E8	0.965			

Note: CR - composite reliability; AVE - average variance extracted.

Discriminant Validity

Discriminant validity was assessed using the HTMT (Franke & Sarstedt, 2019; Henseler et al., 2015), as presented in *Table 6*. HTMT values ranged from 0.546 to 0.943. The highest value was observed between extrinsic factors and intrinsic factors (0.943), whereas all remaining values were below the recommended threshold of 0.90.

The Fornell-Larcker criterion was subsequently examined, as presented in *Table 7*. The results indicate that the square root of the AVE for each construct exceeded its correlations with all other constructs. This demonstrates that each construct shared more variance with its own indicators than with other constructs, supporting construct distinctiveness.

Additional evidence was obtained through HTMT inference using bootstrap confidence intervals. For the relationship between extrinsic factors and intrinsic factors, the 95% confidence interval ranged from 0.898 to 0.987. As the upper confidence limit remained below the critical value of 1.00, the interval did not include unity, providing further support for the distinction between the two constructs.

Although the HTMT value between extrinsic factors and intrinsic factors exceeded the conservative threshold of 0.90, both constructs remain theoretically distinct within Herzberg's Two-Factor Theory. Intrinsic factors reflect achievement, growth, and recognition, whereas extrinsic factors represent working conditions, job security, and salary. While both dimensions

contribute to employees' overall evaluation of their work environment, they capture different aspects of job satisfaction and therefore represent conceptually distinct domains.

Overall, the combined evidence from the HTMT assessment, HTMT inference, and Fornell-Larcker criterion supports the discriminant validity of the retained constructs. Despite the relatively strong association between intrinsic factors and extrinsic factors, the statistical results and theoretical distinction between the constructs justify their retention as separate constructs within the measurement model.

Structural Model Results and Integrated Discussion

The structural model results are presented in *Table 8*. The analysis examined the hypothesised relationships between plantation mechanisation, intrinsic factors, extrinsic factors, and job satisfaction. The significance and practical relevance of the proposed relationships were evaluated using path coefficients (β), *t*-values, *p*-values, and effect sizes (f^2). Collectively, these results provide empirical evidence for assessing the relative contribution of each predictor to job satisfaction among local machine operators in mechanised oil palm estates.

Model Explanatory Power and Effect Size

The structural model demonstrated moderate explanatory power, explaining 37.2% of the variance in job satisfaction (R^2 = 0.372; adjusted R^2 = 0.367). These findings indicate that plantation mechanisation, intrinsic factors, and extrinsic factors collectively explained a meaningful proportion of variation in job satisfaction among local machine operators. At the same time, the unexplained variance suggests that additional organisational, operational, or individual factors may also contribute to employees' overall evaluations of their work.

The effect size analysis further indicates that extrinsic factors exerted the greatest practical influence on job satisfaction (f^2 = 0.077), followed by plantation mechanisation (f^2 = 0.046), whereas intrinsic factors contributed only negligibly (f^2 = 0.003). Although the observed effect sizes are classified as small, they demonstrate that employment conditions and technological experiences contribute meaningfully to employees' work evaluations within mechanised plantation environments. Nevertheless, small effect sizes are commonly observed in organisational and behavioural research because employee attitudes are typically influenced by multiple interrelated factors. Accordingly, statistically significant

TABLE 6. HETEROTRAIT-MONOTRAIT (HTMT)

Construct	Extrinsic factors	Intrinsic factors	Job satisfaction	Plantation mechanisation
Extrinsic factors	–			
Intrinsic factors	0.943	–		
Job satisfaction	0.659	0.546	–	
Plantation mechanisation	0.851	0.847	0.589	–

TABLE 7. FORNELL-LARCKER CRITERION

Construct	Extrinsic factors	Intrinsic factors	Job satisfaction	Plantation mechanisation
Extrinsic factors	0.825			
Intrinsic factors	0.767	0.884		
Job satisfaction	0.574	0.517	0.935	
Plantation mechanisation	0.665	0.704	0.533	0.916

TABLE 8. STRUCTURAL MODEL RESULTS

Path	Coefficient (β)	*t*-value	*p*-value	f^2	Effect interpretation	Result
Extrinsic factors → Job satisfaction	0.356	5.740	<0.001	0.077	Small effect	Supported
Intrinsic factors → Job satisfaction	0.069	1.071	0.284	0.003	Negligible effect	Not supported
Plantation mechanisation → Job satisfaction	0.248	4.045	<0.001	0.046	Small effect	Supported

Note: f^2 - effect sizes.

relationships may still possess meaningful practical relevance despite relatively modest effect sizes.

Structural Relationships

Among the three predictors, extrinsic factors emerged as the strongest determinant of job satisfaction ($\beta = 0.356$, $t = 5.740$, $p < 0.001$). This finding suggests that favourable working conditions, employment security, and remuneration play a more influential role in shaping operators' work evaluations than the other factors examined in the model. Within mechanised plantation environments, employees appear to place considerable importance on stable employment arrangements and organisational support that enable them to perform their work effectively. This finding is consistent with Herzberg's Two-Factor Theory, which proposes that contextual employment conditions constitute an important foundation for employee satisfaction.

Plantation mechanisation also demonstrated a significant positive relationship with job satisfaction ($\beta = 0.248$, $t = 4.045$, $p < 0.001$). Operators who perceived machinery as useful and easy to use reported more favourable evaluations of their work, indicating that positive technological experiences contribute directly to overall job satisfaction. These findings support the TAM by demonstrating that technology-related evaluations extend beyond technology acceptance itself and remain relevant in shaping employees' broader evaluations of their work. In machine-dependent plantation environments, machinery forms an integral component of daily work activities, making technological experiences inseparable from employees' overall work experiences.

In contrast, intrinsic factors did not exert a significant influence on job satisfaction ($\beta = 0.069$, $t = 1.071$, $p = 0.284$). Although respondents generally reported favourable perceptions of achievement, growth, and recognition, these factors did not explain additional variation in job satisfaction after technological perceptions and employment conditions were considered simultaneously. This finding suggests that operators place greater emphasis on the practical conditions under which work is performed, including reliable machinery, organisational support, and employment stability, than on traditional intrinsic sources of motivation. Such a pattern is understandable within mechanised plantation operations, where effective task performance depends heavily on equipment availability, operational continuity and supportive organisational conditions.

Overall, the structural model indicates that job satisfaction among local machine operators is influenced primarily by employment conditions and technological experiences rather than intrinsic motivational factors. Together, these findings support the complementary application of Herzberg's Two-Factor Theory and the TAM by demonstrating that employment conditions and technology-related evaluations jointly shape employees' overall work evaluations within mechanised plantation environments.

Theoretical and Practical Contributions

The findings contribute to plantation workforce research by extending existing studies beyond labour productivity, technology adoption, and operational performance to explain the factors shaping job satisfaction among local machine operators. More specifically, the study demonstrates that technological perceptions and employment conditions should be viewed as complementary rather than independent influences when examining workforce experiences in mechanised plantation environments. By integrating the TAM and Herzberg's Two-Factor Theory, the study extends the application of both theories to a machine-dependent occupational context and demonstrates their combined explanatory value in understanding job satisfaction. The findings further suggest that the influence of mechanisation extends beyond improving operational efficiency to shaping employees' overall evaluations of their work. This finding reinforces the importance of considering technological experiences as part of broader workforce evaluations rather than limiting mechanisation research to operational outcomes alone.

From a practical perspective, the findings indicate that investments in mechanisation alone may be insufficient to strengthen workforce satisfaction. Instead, the benefits of mechanisation are more likely to be realised when technological improvements are accompanied by supportive employment conditions, including reliable machinery, responsive maintenance systems, employment stability and adequate organisational support. Such an integrated approach is likely to enhance both employee satisfaction and the long-term sustainability of mechanised plantation operations.

CONCLUSION

This study examined the factors shaping job satisfaction among local machine operators in Malaysia's mechanised oil palm estates using an integrated framework comprising plantation mechanisation, intrinsic factors and extrinsic factors. The findings indicate that plantation mechanisation and extrinsic factors exert significant

positive effects on job satisfaction, whereas intrinsic factors do not demonstrate a significant influence within the proposed model. The structural model explained 37.2% of the variance in job satisfaction, indicating that technological perceptions and employment conditions account for a meaningful proportion of workforce evaluations within mechanised plantation environments.

The findings support the complementary application of the TAM and Herzberg's Two-Factor Theory in explaining job satisfaction among machine-dependent workers. Extrinsic Factors emerged as the strongest predictor of job satisfaction, followed by plantation mechanisation, highlighting the importance of favourable working conditions, employment stability, remuneration, and positive technological experiences in shaping operators' evaluations of their work. In contrast, intrinsic factors did not contribute significantly when technological perceptions and employment conditions were considered simultaneously, suggesting that operators place greater emphasis on the practical conditions under which work is performed than on traditional intrinsic sources of motivation, such as achievement, growth and recognition.

The study contributes to plantation workforce research by demonstrating that technological perceptions and employment conditions should be understood as complementary influences on job satisfaction rather than as separate explanatory domains. By integrating the TAM and Herzberg's Two-Factor Theory within a single analytical framework, the study extends the application of both theories to machine-dependent plantation work and provides empirical evidence from Malaysia's mechanised oil palm estates, a context that remains underrepresented in the literature. More importantly, the findings suggest that mechanisation influences not only operational performance but also employees' evaluations of their work, thereby broadening current understanding of workforce experiences within mechanised plantation environments.

From a practical perspective, the findings indicate that investments in mechanisation should be complemented by supportive employment conditions to maximise workforce satisfaction. Estate managers should therefore prioritise machinery reliability, responsive maintenance systems, employment stability, adequate remuneration and supportive workplace practices to ensure that the operational benefits of mechanisation translate into positive workforce experiences. Integrating technological investment with effective employment practices is therefore likely to strengthen employee satisfaction while supporting the long-term sustainability of mechanised plantation operations.

Several limitations should be acknowledged. First, the cross-sectional design restricts causal interpretation because all variables were measured at a single point in time. Accordingly, the findings should be interpreted as associative rather than causal despite the theoretically specified directions of the proposed relationships. Second, the reliance on self-reported responses may introduce common method bias. Third, because participation in the online survey was voluntary, the possibility of self-selection bias cannot be entirely excluded. Finally, the focus on local machine operators within Malaysian mechanised oil palm estates may limit the generalisability of the findings to other occupational groups, plantation systems, or national contexts.

Future research should adopt longitudinal research designs to examine how job satisfaction evolves as mechanisation practices and employment conditions change over time. Future studies may also investigate different categories of machine operators and incorporate additional organisational and operational variables, such as supervisory support, workload demands, technological upgrades, maintenance practices and leadership factors, to develop a more comprehensive understanding of workforce experiences within mechanised plantation environments.

Overall, this study demonstrates that the effectiveness of mechanisation should be evaluated not only in terms of operational efficiency and productivity but also through its influence on employees' work experiences. Ultimately, sustainable mechanised plantation operations depend not only on technological capability but also on creating employment conditions that enable machine operators to perform their work effectively and evaluate their work positively.

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