

Navigating the Future: Antecedents and Consequences of Psychology Empowerment in Human-Robot Collaboration within Malaysia's Smart Industries

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Abstract

In recent years, psychological empowerment has gained significant attention in organizational psychology and business contexts. However, its application to human-robot employees, particularly in the domain of collaborative robots (cobots), remains underexplored, especially in Southeast Asia and Malaysia where empirical studies are sparse. This pioneering study addresses this gap by applying Spreitzer's (1995) framework and using PLS-SEM to investigate psychological empowerment among Malaysian cobot-integrated operators in smart manufacturing. The study examines role clarity as a novel moderator alongside traditional antecedents and incorporates authentic leadership and psychological capital as new constructs. Key findings reveal that role clarity significantly enhances the positive effects of psychological empowerment on job engagement but does not impact innovative work behavior. Additionally, authentic leadership and psychological capital are crucial in fostering empowerment. This extended study of the nomological psychology of empowerment provides valuable insights for future research direction on human-robot employees and collaboration dynamics.

Keywords: psychology empowerment, antecedents, consequences, collaborative robots (cobot), AI driven Industry 4.0

1. Introduction

Collaborative robots, or cobots represent a pivotal advancement in industrial automation, designed to work alongside humans in shared environments (Fusko et al., 2018). Initially designed for object manipulation in collaboration with human operators (Colgate et al., 1996), cobots have evolved into versatile, programmable systems with multiple degrees of freedom that are optimized for manufacturing tasks (Djuric et al., 2016). They ensure safety in shared workspaces, being compliant to robotics safety standards such as BS 8611:2016 and ISO 10218-1:2011. The development of cobots also entails the development of related processes like Human-Robot Collaboration (HRC) and Human-Robot Interaction (HRI). The former optimizes productivity and flexibility in tasks like assembly and material handling, while the latter explores communication, trust-building, and acceptance across multiple sectors. It is crucial to study HRC to enhance collaboration effectively as cobots pose unique challenges that will require understanding their psychological impacts on workers and methods of improving their integration into industrial processes.

Empowerment increases organizational flexibility and responsiveness (Mathieu et al., 2006), enhancing both individual and organizational performance (Bordin et al., 2006; Conger & Kanungo, 1988; Dainty et al., 2002; Ozaralli, 2003). According to Spreitzer (1996), empowerment equips individuals with skills, knowledge, and autonomy to influence events, fostering perceived control, competence, and internalization of organizational goals (Menon, 2001). Seibert et al. (2004) highlight an empowering organizational climate in their validated empowerment model, emphasizing its impact on work-unit outcomes and individual performance. This is especially critical especially in the aspect of psychological empowerment.

Psychological empowerment, particularly through decision-making autonomy, enhances task efficiency and performance quality in dynamic work environments (Spreitzer, 1995; Thomas & Velthouse, 1990; Zimmerman, 2000; Aneela et al., 2012). Traits and contextual factors significantly contribute to psychological empowerment (Seibert et al., 2011), consistently linked with positive outcomes like job satisfaction, organizational commitment, and task performance, and negatively associated with employee strain and turnover intentions (Spreitzer, 1995a; Spreitzer, 1995b). Psychological empowerment also encourages employees to assume greater responsibilities (Silen et al., 2019). However, knowledge gaps exist in understanding the individual differences that underpins these relationships especially with regards to cobots. Although a better understanding of this is critical for employee effectiveness and well-being (Corsun & Enz, 1999), its practical application remains underexplored.

Despite Industry 4.0's rapid adoption, the pivotal role of human workers in cobot-integrated sectors is often overlooked. Research at this intersection of technology and organizational psychology is scarce, especially those that concerns how cobot-integrated collaboration affects psychological empowerment and workplace dynamics in East Asia, with particular emphasis on Malaysia. Building on Spreitzer's seminal work (1995a, 1995b), this study employs a correlational approach to deepen the understanding of psychological empowerment (PE) at the level of the individual employee. Through a comprehensive partial nomological network and a model integrating macro and micro factors, the authors aim to uncover hidden antecedents and consequences and the relationship of PE, exploring its direct relationship with contextual factors, individual traits, and organizational dynamics in cobot-integrated manufacturing industries. The objective of this study is to therefore investigate PE's impact on job engagement and innovative work behavior in Malaysia's AI-driven Industry 4.0 among the cobot-integrated industries, aiming to enhance human-robot collaboration and offer insights for academia, policy, and industry.

2. Theoretical Background, Literature Review and Hypothesis Development

This research builds on Psychological Empowerment Theory towards the development of a comprehensive model to address the objective of the study. The framework includes direct-effect hypotheses and explores mediating and moderating effects (see Figure 1).

2.1 Theoretical Background

2.1.1 The Mediating Role of Psychology Empowerment

According to Spreitzer (1995), psychological empowerment is a multidimensional concept that involves beliefs in one's ability to influence the work environment, competence in job tasks, the meaningfulness of work, and autonomy in decision-making. This multidimensional concept includes dimensions such as self-determination, competence, meaning, and impact, contributing to a sense of empowerment within organizations (Srivastava, 2016; Khany & Tazik, 2016; Shogren & Shaw, 2016; Schermuly, 2022; Islam, 2016). Srivastava (2016) emphasizes the importance of internal motivation, which stems from perceptions of task meaningfulness and confidence in task completion, aligning with the principles found in job design literature (Conger & Kanungo, 1988; Thomas & Velthouse, 1990; Koberg, 1999).

2.2 Antecedents of Psychology Empowerment

2.2.1 Locus of Control

Locus of control, defined as individuals' beliefs about the origin of life's outcomes (Rotter, 1966; Kovaleva et al., 2014), can significantly influence job satisfaction, autonomy, and job tenure: this centers on the construct of individuals as internals or externals. Individuals who attribute outcomes to their own efforts (internals) typically experience greater job satisfaction and autonomy (Thomas & Velthouse, 1990; Spector, 1994), and demonstrate proactive behavior (Kusumawati, 2019). In contrast, those who attribute outcomes to external forces (externals) believe in influences like luck or fate (Rotter, 1966). Psychological empowerment enhances self-control, thereby influencing motivation and behavior (Rotter, 1966; Kovaleva et al., 2014). Therefore, we hypothesize that:

H1: Locus of control is positively related to psychological empowerment.

2.2.2 Self esteem

Self-esteem, defined as an individual's subjective evaluation of their own worth (Rosenberg, 1965), correlates positively with psychological empowerment among employees. Higher self-esteem is associated with positive attitudes towards the organization, improved performance, and increased success (Yao et al., 2013; Isci et al., 2013). Empowered employees, whose key indicators include motivation, initiative, and innovation, exhibit positive expectations for success (Spreitzer et al., 1999). Based on the above statement, we hypothesize that:

H2: Self-esteem is positively related to psychological empowerment.

2.2.3 Access to Information, Access to Unit Performance Information, and Access to Information about an Organization's Rewards System

Access to information, as defined by Spreitzer (1996), empowers employees by providing knowledge about organizational goals and strategies; fostering role understanding and alignment with organizational mission (Spreitzer, 1995). This transparency supports effective decision-making and influence (Spreitzer, 1996; Biculi, 2021). Studies by Drake et al. (2007) and Hall (2008) further explore how specific aspects of information access contribute to empowerment. Therefore, we hypothesize that access to information positively impacts employee empowerment.

H3: Access information about the mission of an organization is positively correlated related to psychology empowerment.

Access to comprehensive information about unit performance enhances employees' psychological empowerment, facilitating informed decision-making and effective contributions to organizational goals (Spreitzer, 1995; Lawler et al., 1995; Parker and Kyj, 2006). High-performing units, characterized by evidence of strong collaboration, clear communication, and shared commitment (Spreitzer, 1996), are influenced by factors including empowerment levels, leadership quality, and resource availability. Thus, we propose that:

H4: Access information about the mission of an organization is positively correlated related to psychology empowerment

Access to information about the organizational reward system, encompassing both financial and non-financial incentives (Spreitzer, 1996), enhances empowerment by recognizing individual competencies and sustaining motivation levels (Spreitzer, 1995; Bowen & Lawler, 1992). Empowering employees through rewards increases productivity by enhancing intrinsic motivation and commitment (Spreitzer, 1996; Bowen & Lawler, 1992). Therefore, we hypothesize the following:

H5: Access to information about an organization's reward system is positively correlated with psychological empowerment.

2.2.4 Psychology Capital

Psychological capital (PsyCap), as defined by Luthans and collaborators (Luthans, 2002; Luthans & Youssef, 2004; Luthans, Youssef, & Avolio, 2007), encompasses hope, optimism, efficacy, and resilience. It fosters task efficacy, optimism about success, persistent goal pursuit with adaptive strategies, and resilience in overcoming setbacks (Gardner et al., 2011). Sweetman and Luthans (2010) demonstrated also PsyCap significantly contributes to psychological empowerment: enhancing feelings of autonomy, competence, and impact among employees. Abbas and Raja (2015) further affirmed PsyCap's positive influence on psychological empowerment. As such the following hypothesis has been proposed for this study

H6: Psychological capital (hope, optimism, efficacy, and resilience) is positively correlated with psychological empowerment (meaning, competence, self-determination, and impact).

2.2.5 Authentic Leadership

Authentic leadership, defined by Walumbwa et al. (2008), emphasizes leaders' genuineness, transparency, and ethical behavior, fostering trust and positive organizational outcomes. This style of leadership involves self-awareness and relational transparency with followers (McAuliffe et al., 2019; Neider & Schriesheim, 2011), leading to positive perceived empowerment and engagement among employees (Laschinger et al., 2014; Zhang et al., 2018; Ilies et al, 2005). "Leaders who support employee autonomy, as discussed by Bono and Judge (2003), align with current empowerment theories (Vogt & Murrell, 1990; Sullivan, 1994). Authentic leadership emphasizes the ethical integration of new technologies, clear communication, and empathy (Avolio & Gardner, 2005; Avey et al., 2008). This approach contributes to employee well-being, job satisfaction, and work engagement (Avolio et al., 2004; May et al., 2004)." Thus, we posit the following hypothesis.

H7: Authentic Leadership (I.e.; transparency, moral/ethical, balanced processing and self-awareness) positively correlated to perceived psychology empowerment in cobot-integrated industries.

2.3 Consequences of Psychology Empowerment

2.3.1 Job Engagement

Employee engagement, as defined by Saks (2006), encompasses cognitive, emotional, and behavioral components crucial for individual role performance and organizational development. Psychological empowerment (PsyEmp) has been consistently shown to positively influence both work engagement and organizational engagement

(Bhatnagar, 2012; Stander & Rothmann, 2010; Wang & Liu, 2015; Liden et al., 2000). Psychological empowerment can also enhance engagement, promoting innovation and reducing turnover intention (Stander & Rothmann, 2010; Bhatnagar, 2012). Other related studies further underscore the transformative potential of psychological empowerment in shaping employee engagement (Joo et al., 2016). Building upon this, we propose the following hypothesis:

H8. Perceived psychology empowerment cobot-integrated (i.e. Meaning, competence, self-determination and impact) has the positive significant influence on work engagement.

2.4 Consequences of Psychology Empowerment

2.4.1 Innovative Work Behaviors

Scott and Bruce (1994) define innovative work behaviors as the introduction of new ideas or practices to benefit organizations. Innovative work behavior encompasses proactive and creative actions by employees, distinguishing itself from creativity, which primarily emphasizes idea generation and serves as a catalyst for innovative behavior (de Jong & den Hartog, 2010; Janssen, 2000; Amabile, 1988; Slatten & Mehmetoglu, 2011; Cainelli, 2004). Janssen (2000) and Zhu et al. (2019) delineate innovative work behavior into four key components: idea generation, idea promotion, and idea implementation. A meta-analysis has substantiated the positive impact of psychological empowerment on innovation (Seibert et al., 2011). Components of psychological empowerment—such as autonomy, competence, and meaningfulness—are consistently identified as predictors of innovation (Deci & Ryan, 1991; Spreitzer, 1995; Zhang & Bartol, 2010; Seibert et al., 2011; Bibi & Afsar, 2018; Zhang & Zhou, 2021). Based on this, we propose the following hypothesis:

H9: Perceived psychology empowerment cobot-integrated (i.e. meaning, competence, self-determination and impact) has the positive significant influence to work innovative behavior.

2.5 Moderating Variable: Role Clarity

2.5.1 Role Clarity Moderate Job Engagement and Psychology Empowerment

Despite the significance of role characteristics, research on their impact on job engagement and innovative work behavior (IWB) is limited. Mukherjee and Malhotra (2005) define role clarity as employees' understanding of their roles, responsibilities, and expectations, emphasizing clear communication to minimize ambiguity and enhance performance and satisfaction. It involves knowing task expectations, behaviors, and relevant information (Kelly & Hise, 1980; Adil et al., 2021; Frogeli et al., 2019). Lack of clarity leads to struggles and deviant behaviors (Judge et al., 2006; Bang et al., 2022; Orgambidez et al., 2022). It also goes beyond job descriptions to transparent expectation management (Yadav & Rangnekar, 2016) and positively influences psychological empowerment (Nel et al., 2015; Vullings et al., 2018; Wang et al., 2016). Thus, we propose that:

H10: Role Clarity will moderate the relationship between job engagement and perceived psychology empowerment in cobot-integrated industries (i.e. meaning, competence, self-determination and impact).

2.5.2 Role Clarity Moderate Innovative Work Behavior and Psychology Empowerment

Role clarity (RC) is crucial in defining job expectations (Yadav & Rangnekar, 2016), predicting positive behaviors such as job satisfaction and organizational citizenship (Chung et al., 2021; Adil et al., 2021), and mitigating confusion and stress (Ritter et al., 2016; Frogeli et al., 2019). RC enhances organizational outcomes like job engagement and commitment (Lee & Lee, 2017; Ul-Hassan et al., 2021) and improves efficiency by clarifying role expectations (Samie et al., 2015), thereby empowering employees with job control aligned with organizational goals (Panaccio & Vandenberghe, 2011). Additionally, RC mediates innovative work behavior (IWB), fostering innovation and engagement (Kundu et al., 2021; Xu et al., 2022). Conversely, employees lacking RC may struggle with task effectiveness (Onyemah, 2008). Despite its significance, the role of RC as a moderator in studies on psychological empowerment remains underexplored, thereby motivating the development of our hypotheses.

H11: Role clarity will moderate the relationship between innovative work behavior and perceived psychology empowerment in cobot-integrated industries (i.e. meaning, competence, self-determination and impact).

3. Methodology

3.1 Measurement Scales and Questionnaire Design

The study employed existing scales with minor modifications and incorporated self-constructed questions developed in consultation with experts. A comprehensive ten-page questionnaire, comprising 77 items, was designed based on a thorough review of the literature to ensure content validity. developed in consultation with experts, to assess eleven key constructs encompassing personal traits, contextual factors, and organizational

aspects. Each construct was measured using multiple items adapted from existing literature, ensuring robust content validity. The questionnaire employed a 7-point Likert scale. The specific item questions are available from the authors upon request (refer to appendix 1). Detailed demographic information is available upon request from the authors.

Locus of control: Locus of control using the measurement of five items from adopted Kovaleva et al. (2014). These five items measured the extent to which: I am my own boss, If I work hard, I will successes. Whether at work or in my private life what I do is mainly determined with others. The internal reliability of CR is 0.857.

Self-esteem: Adopted from Rosenberg (1965) Self-Esteem Scale, this is the main instrument for its assessment: It is used in almost half of the empirical studies published in major scientific journals that assessed self-esteem. The internal reliability of CR is 0.851.

Access information (organization mission) Access information (organization mission) was adopted by Bicudo, 2021. Access Information using the measurement of 3 items scales adapted from Bicudo, 2021 The internal reliability of CR is 0.898.

Access to information (Unit Performance) Access to information (United Performance) was adopted by Bicudo, 2021. Access to information (Unit Performance) using the measurement of 4 items scales, adapted from (Bicudo, 2021), -. The internal reliability of CR is 0.907.

The items for the Access to Organizational Rewards were adopted from Bicudo (2021). The internal reliability of CR is 0.913.

Compound Psychological Capital Scale The present study was adopted from the Compound Psychological Capital Scale (CPC-12; Lorenz et al., 2016), and comprises of 12 items with four dimensions: Hope (CR = 0.836), Resilience (CR = 0.887), Optimism (CR = 0.886) and Self-Efficacy (CR = 0.88).

Psychology empowerment For the survey items under psychology empowerment, twelve item scales on four aspects (meaning (CR = 0.885), competence (CR = 0.882), self-determination (CR = 0.891), and impact (CR = 0.909) was adapted from the Spreitzer's Empowerment Scale (1995).

Authentic Leadership. For authentic leadership, the Walumbwa's Authentic Leadership Scale (2008) was adapted consisting of sixteen item scales on four aspects four primary components of authentic leadership - Self-awareness (CR = 0.892). Relational transparency (CR = 0.911). Balance processing (CR = 0.709). Internalized moral perspective (CR = 0.899).

Job Engagement. For the items on Job Engagement, the survey instrument was adapted from Sak, 2006 with a CR of 0.899.

Innovative Work behavior The survey items on Innovative work behavior was adapted from Scott and Bruce (1994). A sample of the 6 items are measured with a CR value of 0.940.

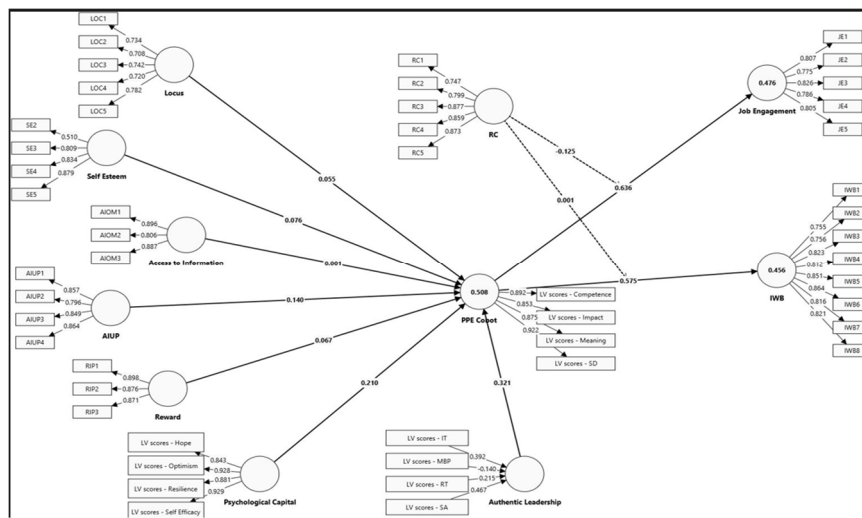
3.2 Study Design and Data Collection

The study employed a purposive sampling method and utilized a quantitative approach with a cross-sectional design to examine personality traits, work behaviors, and job engagement among cobot operators. Data collection took place from January to March 2024. A total of 500 companies listed in the FMM Directory of Malaysian Industries were selected. HR managers from these organizations were contacted to invite cobot-integrated workers to participate in the survey. Invitations were distributed via Google Forms, email, WhatsApp, and LinkedIn to facilitate survey participation. Malaysia Robotic Roadmap 2021 to 2030 sets a robot density target of 195 units per 10,000 employees by 2030, from 55 units per 10,000 employees in 2019 (The Daily Sun, 2023) Among the industrial tasks identified for robotics and advanced automation in NIMP 2030 include welding, assembling, inspecting defects and packaging – all crucial areas which cobots are best designed for (IBID). Hence, our data collection focused on Small and Medium Enterprises (SMEs) and robotic manufacturing companies across Malaysia. The geographical distribution of responses was as follows: Penang (29.11%), Kuala Lumpur (24.8%), Selangor (28.3%), and Johor (18.05%), ensuring broad regional representation. From the survey, 371 usable responses were collected from cobot-integrated operators in various sectors, including electronics, semiconductors, IT solutions, automotive, food and beverage (F&B), and others, resulting in a response rate of 74.2 percent. This high response rate underscores the effectiveness of the recruitment strategy. A power analysis was performed using G*Power software (Memon et al., 2020), which indicated that with 7 predictor variables, an effect size of 0.05, and a desired power of 0.8, the required sample size for detecting the specified effect was 103. The collected sample size of 371 exceeds this requirement, ensuring adequate statistical power for the analysis. This methodological approach provides a robust framework for examining the impact of psychological empowerment

and other variables in the context of human-robot collaboration. The primary instrument of this research is a 77-item survey questionnaire.

4. Data Analysis and Results

4.1 Data Analysis



The Partial Least Squares Structural Equation Modeling (PLS-SEM) using Smart PLS 4.0 software (Ringle et al., 2022) was employed to test the proposed model and hypotheses relationships. The evaluation of the measurement model followed Becker et al. (2022) for indicator reliability, internal consistency, convergent validity, and discriminant validity. To mitigate common method bias (CMB), procedural remedies suggested by Podsakoff et al. (2003) were applied, including pre-validated scales, respondent anonymity, and minimizing evaluation apprehension. Statistical methods recommended by Kock and Lynn (2012) and Kock (2015) confirmed VIF values less than 3.3, indicating no significant bias from single-source data (Table 1).

Table 1. Full collinearity

Variable	VIF
AIUP	3.273
Access to Information	2.920
Authentic Leadership	2.494
IWB	2.256
Job Engagement	2.261
Locus	2.626
PPE Cobot	2.851
Psychological Capital	2.928
RC	2.662
Reward	1.787
Self Esteem	2.481

4.2 Measurement Model

Following the guidelines provided by Hair et al. (2022) and Ramayah et al. (2018), our study confirms the strong reliability and validity of our measurement model. All item loadings exceeded 0.5, while Average Variance Extracted (AVE) and Composite Reliability (CR) scores surpassed recommended thresholds (AVE > 0.5, CR > 0.7). These results validate the measurement items used for our first-order constructs, ensuring their robustness for subsequent analyses.

The study also evaluated the measurement validity and reliability of three second-order constructs within our model. PPE Cobot and Psychological Capital were conceptualized as Type I (Reflective-Reflective), whereas Authentic Leadership was conceptualized as Type II (Reflective-Formative). As shown in Table 2, PPE Cobot and Psychological Capital had Average Variance Extracted (AVE) values of 0.784 and 0.803, with Composite Reliability (CR) values of 0.936 and 0.942, respectively, indicating that both second-order variables were valid and reliable.

Authentic Leadership was assessed in accordance with Hair et al. (2022), starting with the examination of the Variance Inflation Factor (VIF). Table 3 indicates that all VIF values were below 5, suggesting no multicollinearity issues. Subsequently, the t-values for three of the indicators were significant, while one indicator, RT, was only significant at the $p < 0.1$ level. However, RT is considered a theoretically important dimension and was thus retained.

Table 2. Measurement model (Reflective)

Variable	Item	Loadings	CR	AVE
Access to Information	AIOM1	0.901	0.898	0.747
	AIOM2	0.803		
	AIOM3	0.885		
AIUP	AIUP1	0.857	0.907	0.709
	AIUP2	0.790		
	AIUP3	0.851		
	AIUP4	0.870		
IWB	IWB1	0.755	0.940	0.661
	IWB2	0.756		
	IWB3	0.823		
	IWB4	0.812		
	IWB5	0.851		
	IWB6	0.864		
	IWB7	0.816		
	IWB8	0.821		
Job Engagement	JE1	0.807	0.899	0.640
	JE2	0.775		
	JE3	0.826		
	JE4	0.786		
	JE5	0.805		
Locus	LOC1	0.713	0.857	0.545
	LOC2	0.693		
	LOC3	0.756		
	LOC4	0.735		
	LOC5	0.789		
Hope	PC1	0.745	0.836	0.630
	PC2	0.752		
	PC3	0.878		
Optimism	PC4	0.832	0.886	0.665
	PC5	0.799		
	PC6	0.809		
	PC7	0.821		
Self-Efficacy	PC8	0.823	0.887	0.663
	PC9	0.785		
	PC10	0.817		
	PC11	0.831		

Resilience	PC12	0.893	0.887	0.797
	PC13	0.893		
Meaning	PE1	0.818	0.885	0.719
	PE2	0.839		
	PE3	0.885		
Competence	PE4	0.884	0.882	0.789
	PE5	0.892		
SD	PE6	0.855	0.891	0.732
	PE7	0.833		
	PE8	0.878		
Impact	PE9	0.863	0.909	0.768
	PE10	0.865		
	PE11	0.901		
SA	AL1	0.739	0.892	0.675
	AL2	0.847		
	AL3	0.865		
	AL4	0.829		
RT	AL5	0.851	0.911	0.672
	AL6	0.807		
	AL7	0.774		
	AL8	0.825		
	AL9	0.839		
IT	AL10	0.822	0.899	0.690
	AL11	0.840		
	AL12	0.846		
	AL14	0.814		
MBP	AL15	0.642	0.709	0.554
	AL16	0.834		
RC	RC1	0.747	0.918	0.693
	RC2	0.799		
	RC3	0.877		
	RC4	0.859		
	RC5	0.873		
Reward	RIP1	0.899	0.913	0.777
	RIP2	0.879		
	RIP3	0.866		
Self Esteem	SE2	0.536	0.851	0.595
	SE3	0.804		
	SE4	0.834		
	SE5	0.868		

Table 3. Measurement Model Second Order Variables (Reflective/Formative)

Variable	Item	Loadings	CR	AVE
PPE Cobot	Competence	0.892	0.936	0.784
	Impact	0.852		
	Meaning	0.875		
	SD	0.922		
Psychological Capital	Hope	0.844	0.942	0.803
	Optimism	0.928		
	Resilience	0.880		
	Self-Efficacy	0.929		
Authentic Leadership	Item	Weights	t-value	VIF
	IT	0.392	2.767*	3.544
	MBP	-0.140	2.330*	1.015
	RT	0.215	1.365	4.367
	SA	0.467	3.371*	3.341

Note. Weights significant at $p < .05$.

In assessing discriminant validity, this study adhered to Hair *et al.* (2022)'s recommendation to use Heterotrait-Monotrait (HTMT)

ratios of correlations. Traditionally, the Fornell-Larcker criterion and cross-loadings have been utilized for this purpose, but Henseler *et al.* (2015) argued their insufficiency. Franke and Sarstedt (2019) proposed an HTMT threshold of 0.9 for robust evaluation, where values exceeding this indicate potential issues with discriminant validity. As detailed in Table 4, all HTMT values in our study were below 0.9, confirming strong discriminant validity across all constructs. This approach ensures that each construct effectively captures unique phenomena distinct from others in the model, aligning with current methodological best practices.

4.3 Structural Model

As the data was not multivariate normal, we ran a bootstrapping procedure with 10,000 resamples (Becker *et al.*, 2023) to generate the standard deviations and the t-values. The results are presented in Table 5. First, we looked at the R^2 of the respective endogenous variable in our model. The R^2 for PPE Cobot was 0.508, Job Engagement was 0.476 and for Innovative Work Behavior was 0.456. The R^2 values are all acceptable related to the area of research. The exact interpretation of R^2 values depends on the particular model and research discipline. In general, R^2 values of 0.75, 0.05 or 0.25 for the endogenous construct are described as follows: 0.75 (substantial), 0.50 moderate and 0.25 (weak).

AIUP ($\beta = 0.140$, $p < 0.05$), Psychological Capital ($\beta = 0.210$, $p < 0.01$) and Authentic Leadership ($\beta = 0.321$, $p < 0.01$), were all positively related to PPE Cobot while the rest were not significant. Thus, H4, H6 and H7 were supported while H1, H2, H3 and H5 were not supported

PPE Cobot ($\beta = 0.636$, $p < 0.01$) was positively related to Job Engagement while PPE Cobot ($\beta = 0.575$, $p < 0.01$) was also positively related to Innovative Work Behavior, which supports H8 and H9. Finally, to test the moderating effects of Role Clarity on Job Engagement and IWB we used the 2-stage approach to test the interaction effects. RC*PPE Cobot \rightarrow Job Engagement ($\beta = -0.125$, $p < 0.01$) was significant while RC*PPE Cobot \rightarrow IWB ($\beta = 0.001$, $p > 0.05$) was not significant. Thus, H10 was supported while H11 was not supported.

Finally, to visualize the interaction effect we present the interaction plot as shown in Figure 1. As can be seen from Figure 3, the relationship between Cobot Psychological Empowerment and Job Engagement is weaker when Role Clarity is higher.

Table 5. Hypotheses testing

Variables	1	2	3	4	5	6	7	8	9	10	11
1. AIUP											
2. Access to Information	0.840										
3. Authentic Leadership	0.697	0.633									
4. IWB	0.504	0.438	0.554								
5. Job Engagement	0.475	0.414	0.508	0.735							
6. Locus	0.575	0.525	0.757	0.552	0.557						
7. PPE Cobot	0.619	0.540	0.704	0.714	0.749	0.631					
8. Psychological Capital	0.627	0.570	0.691	0.561	0.520	0.815	0.655				
9. RC	0.760	0.707	0.644	0.536	0.530	0.551	0.670	0.713			
10. Reward	0.723	0.595	0.546	0.328	0.374	0.414	0.469	0.390	0.609		
11, Self Esteem	0.609	0.532	0.788	0.552	0.615	0.892	0.643	0.770	0.635	0.390	

As per Shmueli et al. (2019), our study employed the PLSpredict methodology, which utilizes a holdout sample-based procedure to assess predictive relevance using PLS-Predict with a 10-fold cross-validation. As detailed in Table 5, the majority of the item differences (PLS-LM) for both Job Engagement and Innovative Work Behavior (IWB) indicators were lower than those of the LM model. This finding indicates moderate predictive power for our model, suggesting that it effectively predicts outcomes at a satisfactory level. This approach supports the robustness of our findings in predicting both Job Engagement and IWB based on the model's performance in the validation procedure.

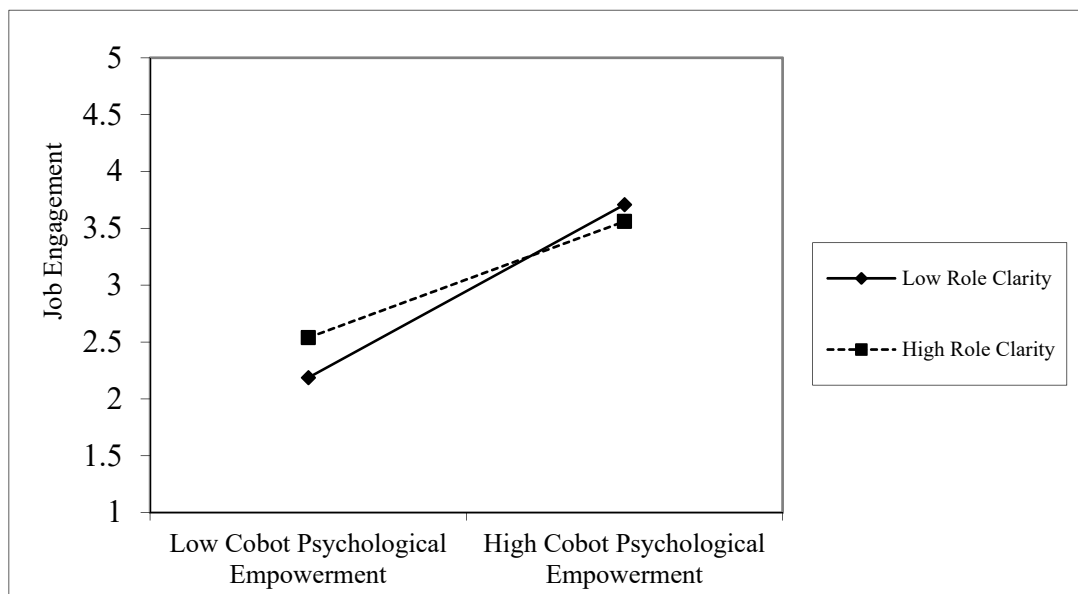


Figure 1. Moderating Effect of Role Clarity on the Cobot Psychological Empowerment and Job Engagement Relationship

5. Findings and Discussion

Our research introduces and validates a multidimensional measure of psychological empowerment in Malaysia’s cobot-integrated workplaces, confirming distinct contributions of its four dimensions through second-order factor analysis.

5.1 Main direction result findings

Hypothesis1: Our study challenges earlier findings by showing no positive link between locus of control and psychological empowerment, diverging from previous research (Rahim, 1996; Bernardi, 1997). This discrepancy can be attributed to differences in conceptualization, measurement methods, sample demographics, and research

contexts. In the context of anxiety and social desirability surrounding cobots, the influence of locus of control is intricate, shaped by diverse cultural, organizational, social, governmental, and educational factors in Malaysia. Our findings suggest that empowerment is more effectively nurtured through collective efforts, social support networks, and external initiatives rather than individual beliefs about control, supporting the insights of Spreitzer (1995).

Hypothesis 2: Self-esteem. The study found no significant relationship between self-esteem and psychological behaviors in cobot-integrated environments, contrary to previous research (Spreitzer, 1999; Baumeister et al., 2003). This discrepancy may be influenced by cultural norms, organizational practices, and specific industry demands in Malaysia, which could moderate the expected relationship.

Hypothesis 3 and 5: Access Information and Reward System: Our study challenges established views on how access to information and reward systems affect psychological empowerment (PE). Contrary to prior research (Spreitzer, 1995; Thomas & Velthouse, 1990; Chiles & Zorn, 1995; Biculi, 2021), we found that access to information via cobots did not significantly enhance PE and sometimes fostered rivalry among employees, undermining collaboration crucial for PE (Kanter, 1977). Instead, our findings underscore the importance of training, job re-definition, and fostering collaborative culture values in promoting PE (Parker & Kyj, 2006).

Regarding the access to organizational rewards system, the findings from our study diverges from the observations from previous studies (Spreitzer, 1995; Thomas & Velthouse, 1990; Bowen & Lawler, 1992; McElroy, 2001; Disch et al., 2004): In Malaysia's cobot-integrated integration context, monetary incentives showed weak correlation with PE. Instead, intrinsic motivators such as job meaningfulness and autonomy were crucial, reflecting Malaysian cultural values that prioritize intrinsic over material rewards, aligned with Maslow's hierarchy of needs. Our study focuses specifically on cobot-integrated operators in lower organizational levels, providing unique insights into their perspectives and needs concerning psychological empowerment.

Hypothesis H4: Access to unit performance Our study shows a significant and positive relationship between access to unit performance (AIUP), with perceived psychological empowerment (PPE) in the context of cobot-integrated integration. Access to unit performance information plays a crucial role in fostering psychological empowerment among employees by enhancing their feelings of competence and self-determination, aligning with prior research (Spreitzer, 1996). Specifically, in cobot-integrated integration, access to performance data enables employees to understand their contributions, feel competent in their roles, and actively engage in their work unit's performance. This finding highlights how strategic information access positively impacts employee empowerment within organizations.

Hypothesis 6: Psychology Capital The finding of our study confirms that PsyCap precedes psychological empowerment, consistent with (Luthans, Youssef, & Avolio, 2007; Avey et al., 2008). Higher PsyCap levels predict increased psychological empowerment, leading to enhanced job satisfaction, performance, and innovative behavior. PsyCap, encompassing self-efficacy, optimism, hope, and resilience, provides critical psychological resources that empower employees through perceptions of meaningful work, autonomy, and competence. This highlights the crucial role of cultivating PsyCap in fostering a positive and resilient workplace culture.

Hypothesis 7: Authentic Leadership Authentic leadership profoundly shapes employees' perceptions of workplace technology, particularly in Malaysia's cobot-integrated industries. Leaders who embody transparency and integrity foster trust and collaboration, encouraging employees to see cobots as tools for collective progress. The findings from our study suggests that authentic leadership do positively impact psychological empowerment, enhancing job satisfaction, commitment, and performance (Avey et al., 2008; Norman et al., 2008; Stander & Rothmann, 2010; Walumbwa et al., 2008; Avolio & Gardner, 2005; Seibert et al., 2011;). This underscores the critical role of authentic leadership in empowering employees.

5.2 The Consequences Intervention of Psychology Empowerment

Hypothesis H8: Job Engagement Our study finds a significant relationship between psychological empowerment (PE) and job engagement. Empowered employees, feeling competent, autonomous, and engaged in meaningful work, interact positively with cobots, optimize processes, and show enthusiasm, thereby enhancing productivity and efficiency (Stander & Rothmann, 2010; Bhatnagar, 2012; Ugwu et al., 2014; Wang & Liu, 2015; Joo et al., 2016).

Hypothesis 9: Innovative Work Behavior. Our study confirms a significant positive association between psychological empowerment and innovative work behavior, consistent with current literature (Spreitzer, 1995; Zhang & Bartol, 2010; Seibert et al., 2011; Hassan et al., 2024;). Positive experiences with cobots enhance employees' innovation by streamlining processes, promoting idea exploration, and problem-solving.

Empowerment dimensions consistently correlate with positive outcomes such as innovation and job effectiveness.

Hypothesis 10: Role clarity moderates job engagement and psychological empowerment: The findings align with Whitaker *et al.* (2007), showing that employees with clearer understandings of their roles and responsibilities demonstrate higher performance levels. Psychologically empowered employees, possessing greater autonomy and competence, navigate challenges effectively, particularly in dynamic environments such as human-robot interaction. Role clarity, as defined by Yadav and Rangnekar (2016), enhances employee engagement by establishing clear performance expectations (Frogeli *et al.*, 2019). This clarity strengthens the relationship between empowerment, job satisfaction, and well-being, underscoring its critical role in technology-integrated workplaces.

Hypothesis 11: Our study challenges the assumption that high role clarity practices automatically lead to significant outcomes in innovative work behavior and psychological empowerment. Consistent with Lynn and Kalay (2015) and Jada *et al.* (2019), we find that while high role clarity does not consistently yield positive results, its absence can lead to role conflict and stress (Ahmad *et al.*, 2021). Conversely, lower role clarity can encourage creativity by fostering diverse perspectives (Lee *et al.*, 2018). Our findings emphasize that while role clarity provides organizational structure, psychological empowerment relies more on intrinsic motivation and flexibility: qualities that rigid roles may restrict. Environments conducive to both psychological empowerment and innovation are therefore more dynamic and supportive of risk-taking, thus enabling creative autonomy (Deci & Ryan, 1985; Kundu *et al.*, 2019).

5.3 Research Implications

5.3.1 Theoretical Implications

Our research extends Spreitzer's model by integrating authentic leadership and Psychological Capital (PsyCap) as critical antecedents of psychological empowerment, focusing on enhancing job engagement and innovative work behavior in AI-driven industries. This theoretical advancement underscores our contribution to organizational behavior (OB), providing insights into how transparency, trust, and resilience can sustain organizational effectiveness and employee well-being. Additionally, by highlighting role clarity as a novel moderator, this study offers an alternative to traditional assumptions and proposes adaptive strategies that harmonize empowerment and innovation alongside technological advancements. Our study enriches OB theories by deepening the understanding of cobots interactions, guiding HR practices and policies to optimize employee well-being in the evolving Industry 4.0 landscape, particularly during early cobot integration in Asia.

5.3.2 Practical Implications

This study emphasized systematic approaches to fostering employee empowerment alongside technological advancements. The integration of psychological empowerment and job engagement can enhance human-robot collaboration in cobot-driven industries, boosting productivity and innovation (Baraglia *et al.*, 2017; Maslarić *et al.*, 2016). Therefore, the cultivation of an empowerment-focused culture is crucial for effective human-robot interactions in dynamic markets. Accessing cobot information via intuitive interfaces can improve efficiency (Kaasinen *et al.*, 2020) while empowerment can nurture motivation and skills with varying results by individuals (Heslin, 1999). Tailored strategies that readiness and autonomy are vital (Yilma *et al.*, 2019). Comprehensive training and a collaborative culture optimize interaction and adaptability (Snell & Dean, 1992). Intrinsic motivators and a supportive environment sustain empowerment (Seibert *et al.*, 2004). AI Leadership should build trust and skills, involving employees (Ergeneli *et al.*, 2007). Integrating empowerment into cobot-integrated models enhances effectiveness through profiling, designs, personalized rewards, and improved information access in the workplace.

5.4 Limitation of Study and Future Direction

This study is limited by its reliance on cross-sectional data, thus potentially affecting causal interpretations. Self-reported measures may contribute to or introduce biases, and the specific cultural focus of the sample may limit generalization of the findings. The absence of longitudinal exploration also restricts insights into empowerment dynamics over time.

Future research should employ longitudinal designs and integrate objective assessments to enhance methodological rigor across diverse cultural contexts. Diversification of samples should also enhance applicability, and with the exploring systemic impacts and societal outcomes of empowerment informing socioeconomic development strategies. Future research on psychological empowerment (PE) in AI-driven workplaces should focus on several key areas to enhance our understanding and application. Investigating cultural nuances will ensure that empowerment strategies are culturally appropriate and effective across diverse environments. Adapting assessment tools to reflect the unique aspects of AI and cultural diversity will improve measurement accuracy.

Additionally, examining organizational factors like climate and diversity can provide insights into creating more inclusive and supportive workplaces.

6. Conclusion

This study pioneers the integration of psychological empowerment (PE) with AI in modern workplaces, shedding light on the complexities of human-robot collaboration. By examining how PE influences and interacts within AI-driven environments, the research enhances our understanding of its impact on employee engagement and innovative work behaviors. Extending the nomological study of psychological empowerment will address the study's limitations by incorporating longitudinal designs, which can provide insights into how empowerment dynamics evolve over time. Additionally, exploring moderators such as technological trust and adapting assessment tools for diverse environments will improve measurement accuracy and relevance. These approaches will refine our understanding of empowerment dynamics and guide the development of effective strategies to enhance employee engagement and innovation across various industrial sectors.

Ethical Statement/Approval

The data collected and analyzed in this research were obtained solely from the survey instrument, with explicit consent obtained from the participants and with no sensitive information; hence, ethical approval was determined as being not necessary.

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Credit authorship contribution statement

1. Jenny Marisa Lim Dao Siang Investigation, Conceptualization, Methodology, Writing Original Draft, Writing Review, Project Administration
2. Prof Ramayah Thuraisamy Formal analysis and Validation
3. Julian Ming Sung Cheng; Conceptualization, Methodology, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal and publisher adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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References

- Abbas, M., & Raja, U. (2015). Impact of psychological capital on innovative performance and job stress. *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'administration*, 32(2), 128-138. <https://doi.org/10.1002/cjas.1269>
- Adil, A., Kausar, S., & Shujja, S. (2023). Impact of organizational socialization on organizational citizenship behavior: Mediating role of knowledge sharing and role clarity. *Current Psychology*, 42(4), 5685-5693. <https://doi.org/10.1007/s12144-021-01899-x>
- Amabile, T. M. (1988). A model of creativity and innovation in organizations. *Research in Organizational Behavior*, 10, 123-167.
- Aneela, A., Tahira, M. T., Sobia, R., & Muhammad, J. (2012). Empowerment effects and employees' job satisfaction. *Academic Research International*, 2(3).
- Avey, J. B., Hughes, L. W., Norman, S. M., & Luthans, K. W. (2008). Using positivity, transformational leadership, and empowerment to combat employee negativity. *Leadership & Organization Development Journal*, 29(2), 110-126. <https://doi.org/10.1108/01437730810859574>
- Avey, J. B., Reichard, R. J., Luthans, F., & Mhatre, K. H. (2011). Meta-analysis of the impact of positive psychological capital on employee attitudes, behaviors, and performance. *Human Resource Development Quarterly*, 22(2), 127-152. <https://doi.org/10.1108/01437730810852470>
- Avey, J. B., Wernsing, T. S., & Luthans, F. (2008). Can positive employees help positive organizational change? Impact of psychological capital and emotions on relevant attitudes and behaviors. *The Journal of Applied Behavioral Science*, 44(1), 48-70. <https://doi.org/10.1177/0021886307311470>
- Avolio, B. J., & Gardner, W. L. (2005). Authentic leadership development: Getting to the root of positive forms of leadership. *The Leadership Quarterly*, 16(3), 315-338. <https://doi.org/10.1016/j.leaqua.2005.03.002>
- Bang, H., Lee, C., & Chen, L. (2022). Exploring attitudes of mandatory volunteers: The role of perceived organizational support, role clarity, and self-efficacy toward service. *Nonprofit and Voluntary Sector Quarterly*, 52(2), 246-266. <https://doi.org/10.1177/08997640221093797>
- Baraglia, J., Cakmak, M., & Asada, M. (2017). Efficient human-robot collaboration: When should a robot take initiative? *The International Journal of Robotics Research*, 36(5-7), 703-720. <https://doi.org/10.1177/0278364916688253>
- Baumeister, R. F., Campbell, J. D., Krueger, J. I., & Vohs, K. D. (2003). Does high self-esteem cause better performance, interpersonal success, happiness, or healthier lifestyles? *Psychological Science in the Public Interest*, 4(1), 1-44. <https://doi.org/10.1111/1529-1006.01431>
- Becker, J. M., Cheah, J. H., Gholamzade, R., Ringle, C. M., & Sarstedt, M. (2023). PLS-SEM's most wanted guidance. *International Journal of Contemporary Hospitality Management*, 35(1), 321-346. <https://doi.org/10.1108/IJCHM-04-2022-0474>
- Bernardi, R. A. (1997). The relationships among LOC, perceptions of stress, and performance. *Journal of Applied Business Research*, 13(4), 1-8. <https://doi.org/10.19030/jabr.v13i4.5736>
- Bhatnagar, J. (2012). Management of innovation: Role of psychological empowerment, work engagement, and turnover intention in the Indian context. *International Journal of Human Resource Management*, 23(5), 928-951. <https://doi.org/10.1080/09585192.2012.651313>
- Bibi, A., & Afsar, B. (2018). Leader-member exchange and innovative work behavior: The role of intrinsic motivation, psychological empowerment, and creative process engagement. *Perspectives of Innovations, Economics and Business*, 18, 25-43. <https://doi.org/10.15208/pieb.2017.3>
- Bicudo de Castro, V., & Sridharan, V. G. (2022). Advancing empowerment research in management control: The effects of access to information and deadlines. *Pacific Accounting Review*, 34(1), 23-48. <https://doi.org/10.1108/PAR-05-2020-0052>
- Bono, J. E., & Judge, T. A. (2003). Self-concordance at work: Toward understanding the motivational effects of transformational leaders. *Academy of Management Journal*, 46, 554-571. <https://doi.org/10.2307/1556491>
- Bordin, C., Bartram, T., & Casimir, G. (2006). The antecedents and consequences of psychological empowerment among Singaporean IT employees. *Management Research News*, 29(4), 34-46. <https://doi.org/10.1108/01409170710724287>

- Bowen, D., & Lawler, E. (1992). The empowerment of service workers: What, why, how, and when. *Sloan Management Review*, 33(3), 31-39.
- BS 8611:2016: Robots and robotic devices. Guide to the ethical design and application of robots and robotic systems: British Standards Institutions.
- Cainelli, G. (2004). Innovation and economic performance: In search of theoretical foundations. *Economics of Innovation and New Technology*, 13(4), 285-298.
- Choo, F. (1986). Job stress, job performance, and auditor personality characteristics. *Journal of Accounting Research*, 24(1), 1-18. <https://doi.org/10.2307/2491104>
- Chung, M., Jang, Y. H., & Edelson, S. A. (2021). The path from role clarity to job satisfaction: Natural acting and the moderating impact of perceived fairness of compensation in services. *Service Business*, 15(1), 77-102. <https://doi.org/10.1007/s11628-020-00434-5>
- Colgate, E. J., Wannasuphprasit, W., & Peshkin, M. A. (1996). Cobots: Robots for collaboration with human operators. *Proceedings of the International Mechanical Engineering Congress and Exhibition, Atlanta, DSC-Vol. 58*, 433-439. <https://doi.org/10.1115/IMECE1996-0367>
- Conger, J. A., & Kanungo, R. N. (1988). The empowerment process: Integrating theory and practice. *Academy of Management Review*, 13(3), 471-482. <https://doi.org/10.5465/amr.1988.4306983>
- Corsun, D. L., & Enz, C. A. (1999). Predicting psychological empowerment among service workers: The effect of support-based relationships. *Human Relations*, 52(2), 205-224. <https://doi.org/10.1177/001872679905200204>
- De Jong, J. P. J., & Den Hartog, D. N. (2010). Measuring innovative work behavior. *Creativity and Innovation Management*, 19(1), 23-36. <https://doi.org/10.1111/j.1467-8691.2010.00547.x>
- Deci, E. L., & Ryan, R. M. (1991). A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), *Nebraska symposium on motivation: Vol. 38. Perspectives on motivation* (pp. 237-288). University of Nebraska Press.
- Djuric, A. M., Urbanic, R. J., & Rickli, J. L. (2016). A framework for collaborative robot (CoBot) integration in advanced manufacturing systems. *SAE International Journal of Materials and Manufacturing*, 9(2), 457-464. <https://doi.org/10.4271/2016-01-0337>
- Drake, A., Wong, J., & Salter, S. (2007). Empowerment, motivation, and performance: Examining the impact of feedback and incentives on nonmanagement employees. *Behavioral Research in Accounting*, 19(1), 71-89. <https://doi.org/10.2308/bria.2007.19.1.71>
- EN ISO 10218-1:2011. Robots and robotic devices - Safety requirements for industrial robots - Part 1: Robots (ISO 10218-1:2011).
- Ergeneli, A., Arı̇n, G., & Metin, S. (2007). Psychological empowerment and its relationship to trust in immediate managers. *Journal of Business Research*, 60(1), 41-49. <https://doi.org/10.1016/j.jbusres.2006.12.001>
- Frogeli, E., Rudman, A., & Gustavsson, P. (2019). The relationships between task mastery, role clarity, social acceptance, and stress: An intensive longitudinal study with a sample of newly registered nurses. *International Journal of Nursing Studies*, 91, 60-69. <https://doi.org/10.1016/j.ijnurstu.2019.02.002>
- Fusko, M., Miroslav, M. M., Martin, R., Luboslar, D., & Martin, G. (2018). Basics of designing maintenance processes in Industry 4.0. *MM Science Journal*, 450-459. https://doi.org/10.17973/MMSJ.2018_03_2017104
- Gardner, W. L., Avolio, B. J., Luthans, F., May, D. R., & Walumbwa, F. (2005). Can you see the real me? A self-based model of authentic leader and follower development. *The Leadership Quarterly*, 16(3), 343-372. <https://doi.org/10.1016/j.leaqua.2005.03.002>
- Gardner, W. L., Cogliser, C. C., Davis, K. M., & Dickens, M. P. (2011). Authentic leadership: A review of the literature and research agenda. *The Leadership Quarterly*, 22(6), 1120-1145. <https://doi.org/10.1016/j.leaqua.2011.09.006>
- Hair, J. F., Thomas, G., Hult, M., Ringle, C. M., & Sarstedt, M. (2022). *A Primer on Partial Least Squares Structural Equation Modelling (3rd ed.)*. Thousand Oaks, CA: Sage. <https://doi.org/10.1007/978-3-030-80519-7>
- Hall, M. (2008). The effect of comprehensive performance measurement systems on role clarity, psychological empowerment, and managerial performance. *Accounting, Organizations and Society*, 33(2-3), 141-163.

<https://doi.org/10.1016/j.aos.2007.03.001>

- Hartog, D. N. D., & De Jong, J. P. J. (2010). Measuring innovative work behavior. *Creativity and Innovation Management, 19*(1), 23-36. <https://doi.org/10.1111/j.1467-8691.2010.00547.x>
- Hassan, R. S., Amin, H. M. G., & Ahmed, H. (2024). Decent work and innovative work behavior of academic staff in higher education institutions: The mediating role of work engagement and job self-efficacy. *Humanities and Social Sciences Communications, 11*(1), Article 177. <https://doi.org/10.1057/s41599-024-03177-0>
- Henseler, J., Ringle, C., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115-135. <https://doi.org/10.1007/s11747-014-0403-8>
- Heslin, P. A. (1999). Boosting empowerment by developing self-efficacy. *Asia Pacific Journal of Human Resources, 37*(1), 52-65. <https://doi.org/10.1177/103841119903700105>
- Ilies, R., Morgeson, F. P., & Nahrgang, J. D. (2005). Authentic leadership and eudaemonic well-being: Understanding leader-follower outcomes. *The Leadership Quarterly, 16*(3), 373-394. <https://doi.org/10.1016/j.leaqua.2005.03.003>
- Isci, E., Ergeneli, A., & Ari, G. S. (2013). Psychological empowerment and its relationship with trust in immediate managers. *Journal of Business Research, 66*(2), 62-82. <https://doi.org/10.1016/j.jbusres.2012.04.016>
- Islam, T., Ahmed, I., Ali, G., Ali, S. I., & Qureshi, M. A. (2016). The impact of psychological empowerment on employee's job satisfaction: A study of banking sector in Pakistan. *Journal of Basic and Applied Scientific Research, 6*(4), 7-12.
- Jada, U. R., Mukhopadhyay, S., & Titiyal, R. (2019). Empowering leadership and innovative work behavior: A moderated mediation examination. *Journal of Knowledge Management, 23*(5), 915-930. <https://doi.org/10.1108/JKM-08-2018-0533>
- Janssen, O. (2000). Job demands, perceptions of effort-reward fairness and innovative work behavior. *Journal of Occupational and Organizational Psychology, 73*(3), 287-302. <https://doi.org/10.1348/096317900167038>
- Joo, B. K., Lim, T., & Kim, S. (2016). Enhancing work engagement: The roles of psychological capital, authentic leadership, and work empowerment. *Leadership & Organization Development Journal, 37*(8), 1117-1134. <https://doi.org/10.1108/LODJ-01-2015-0005>
- Judge, T. A., Scott, B. A., & Ilies, R. (2006). Hostility, job attitudes, and workplace deviance: Test of a multilevel model. *Journal of Applied Psychology, 91*(1), 126-138. <https://doi.org/10.1037/0021-9010.91.1.126>
- Kaasinen, E., Schmalfuß, F., Öztürk, C., Aromaa, S., Boubekeur, M., Heilala, J., Heikkilä, P., Kuula, T., Liinasuo, M., Mach, S., Mehta, R., Petäjä, E., & Walter, T. (2020). Empowering and engaging industrial workers with Operator 4.0 solutions. *Computers & Industrial Engineering, 139*, Article 105678. <https://doi.org/10.1016/j.cie.2019.01.052>
- Kanter, R. M. (1977). *Men and women of the corporation*. Basic Books, New York.
- Kelly, J. P., & Hise, R. T. (1980). Role conflict, role clarity, job tension and job satisfaction in the brand manager position. *Journal of the Academy of Marketing Science, 8*(1), 27-35. <https://doi.org/10.1007/BF02725595>
- Khany, R., & Tazik, K. (2016). The relationship between psychological empowerment and organizational commitment: A field study in Iran. *Global Business and Organizational Excellence, 35*(1), 34-45. <https://doi.org/10.1002/joe.21664>
- Koberg, C. S., Boss, R. W., Senjem, J. C., & Goodman, E. A. (1999). Antecedents and outcomes of empowerment: Empirical evidence from the health care industry. *Group & Organization Management, 24*(1), 71-91. <https://doi.org/10.1177/1059601199241005>
- Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration, 11*(4), 1-10. <https://doi.org/10.4018/ijecl.2015100101>
- Kock, N., & Lynn, G. S. (2012). Lateral collinearity and misleading results in variance-based SEM: An illustration and recommendations. *Journal of the Association for Information Systems, 13*(7), 546-580. <https://doi.org/10.17705/1jais.00331>
- Kovaleva, A., Beierlein, C., Kemper, C. J., & Rammstedt, B. (2014). Internal-external locus of control-4 (IE-4) – Scale for the assessment of internal and external locus of control. In *Zusammenstellung*

- sozialwissenschaftlicher Items und Skalen (ZIS)*. GESIS - Leibniz Institute for the Social Sciences.
- Kundu, S. C., Kumar, S., & Lata, K. (2019). Effects of perceived role clarity on innovative work behavior: A multiple mediation model. *RAUSP Management Journal*, *54*(3), 281-295. <https://doi.org/10.1108/RAUSP-07-2018-0174>
- Kusumawijaya, K. I. (2019). The prediction of need for achievement to generate entrepreneurial intention: A locus of control mediation. *International Review of Management and Marketing*, *9*(4), 54-62. <https://doi.org/10.32479/irmm.8330>
- Laschinger, H. K. S., Wong, C. A., Cummings, G. G., & Grau, A. L. (2014). Resonant leadership and workplace empowerment: The value of positive organizational cultures in reducing workplace incivility. *Nursing Economics*, *32*(1), 5-44.
- Lawler, E. E., Mohrman, S. A., & Ledford, G. E. (1995). *Creating high performance organizations: Practices and results of employee involvement and total quality management in Fortune 1000 companies*. Jossey-Bass, San Francisco, CA.
- Lee, W. J., & Lee, J. K. (2017). Role clarity and organizational commitment in food manufacturing and distribution firms: The mediating role of creativity. *The Journal of Distribution Science*, *15*(1), 115-121. <https://doi.org/10.15722/jds.15.1.201701.115>
- Liden, R. C., Wayne, S. J., & Sparrowe, R. T. (2000). An examination of the mediating role of psychological empowerment on the relations between the job, interpersonal relationships, and work outcomes. *Journal of Applied Psychology*, *85*(3), 407-416. <https://doi.org/10.1037/0021-9010.85.3.407>
- Luthans, F., & Youssef, C. M. (2004). Human, social, and now positive psychological capital management: Investing in people for competitive advantage. *Organizational Dynamics*, *33*(2), 143-160. <https://doi.org/10.1016/j.orgdyn.2004.01.003>
- Luthans, F., Avolio, B. J., Avey, J. B., & Norman, S. M. (2007). Positive psychological capital: Measurement and relationship with performance and satisfaction. *Personnel Psychology*, *60*(3), 541-572. <https://doi.org/10.1111/j.1744-6570.2007.00083.x>
- Luthans, F., Youssef, C. M., & Avolio, B. J. (2007). *Psychological capital: Developing the human competitive edge*. Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780195187526.001.0001>
- Lynn, T., & Kalay, F. (2015). Role clarity and innovative behavior in the workplace: A meta-analysis. *Journal of Applied Social Psychology*, *45*(2), 75-87. <https://doi.org/10.1111/jasp.12273>
- Maslarić, M., Nikoličić, S., & Mirčetić, D. (2016). Logistics response to the industry 4.0: The Physical Internet. *Open Engineering*, *6*(1), 511-517. <https://doi.org/10.1515/eng-2016-0058>
- Mathieu, J. E., Gilson, L. L., & Ruddy, T. M. (2006). Empowerment and team effectiveness: An empirical test of an integrated model. *Journal of Applied Psychology*, *91*(1), 97-108. <https://doi.org/10.1037/0021-9010.91.1.97>
- May, D. R., Gilson, R. L., & Harter, L. (2004). The psychological conditions of meaningfulness, safety and availability and the engagement of the human spirit at work. *Journal of Occupational and Organizational Psychology*, *77*(1), 11-37. <https://doi.org/10.1348/096317904322915892>
- McAuliffe, N., Bostain, N. S., & Witchel, A. D. (2019). The relationship between authentic leadership, trust, and engagement in library personnel. *Journal of Library Administration*, *59*(1), 129-148. <https://doi.org/10.1080/01930826.2018.1562822>
- McElroy, J. C. (2001). Managing workplace commitment by putting people first. *Journal of Organizational Behavior*, *22*(8), 815-835. <https://doi.org/10.1002/job.122>
- Memon, M. A., Ting, H., Cheah, J. H., Thuramy, R., Chuah, F., & Cham, T. H. (2020). Sample size for survey research: Review and recommendations. *Journal of Applied Structural Equation Modeling*, *4*(2), 1-20. [https://doi.org/10.47263/JASEM.4\(2\)01](https://doi.org/10.47263/JASEM.4(2)01)
- Menon, S. T. (2001). Employee empowerment: An integrative psychological approach. *Applied Psychology: An International Review*, *50*(1), 153-180. <https://doi.org/10.1111/1464-0597.00062>
- MM, S. (2021). Influence of empowerment, psychological contract, and employee engagement on voluntary turnover intentions. *International Journal of Productivity and Performance Management*, *70*(2), 325-349. <https://doi.org/10.1108/IJPPM-04-2019-0189>

- Mukherjee, A., & Malhotra, N. (2005). Antecedents and consequences of role clarity in explaining employee-perceived service quality in call centers. *American Marketing Association*, 17(1), 15-17. <https://doi.org/10.1108/09564230610689777>
- Nel, W., Stander, M. W., & Latif, J. (2015). Investigating positive leadership, psychological empowerment, work engagement, and satisfaction with life in a chemical industry. *SA Journal of Industrial Psychology*, 41(1), 1-13. <https://doi.org/10.4102/sajip.v41i1.1243>
- Newman, A., Ucbasaran, D., Zhu, F., & Hirst, G. (2014). Psychological capital: A review and synthesis. *Journal of Organizational Behavior*, 35(S1), S120-S138. <https://doi.org/10.1002/job.1924>
- Onyemah, V. (2008). Role ambiguity, role conflict, and performance: Empirical evidence of an inverted-U relationship. *Journal of Personal Selling & Sales Management*, 28(4), 299-314. <https://doi.org/10.2753/PSS0885-3134280306>
- Orgambáidez, A., Millán, M., Domínguez, L., & Borrego, Y. (2021). Structural empowerment, burnout, and job satisfaction: Comparison of public and private social service centers. *International Journal of Social Welfare*, 30(1), 82-95. <https://doi.org/10.1111/ijsw.12441>
- Özaralli, N. (2003). Effects of transformational leadership on empowerment and team effectiveness. *Leadership & Organization Development Journal*, 24(6), 335-344. <https://doi.org/10.1108/01437730310494301>
- Panaccio, A., & Vandenberghe, C. (2011). The relationships of role clarity and organization-based self-esteem to commitment to supervisors and organizations and turnover intentions. *Journal of Applied Social Psychology*, 41(6), 1455-1485. <https://doi.org/10.1111/j.1559-1816.2011.00787.x>
- Parker, R. J., & Kyj, L. (2006). Vertical information sharing in the budgeting process. *Accounting, Organizations and Society*, 31(1), 27-45. <https://doi.org/10.1016/j.aos.2005.03.003>
- Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879-903. <https://doi.org/10.1037/0021-9010.88.5.879>
- Rahim, M. A., & Psenicka, C. (1996). A structural equations model of stress, locus of control, social support, psychiatric symptoms, and propensity to leave a job. *The Journal of Social Psychology*, 136(1), 69-84. <https://doi.org/10.1080/00224545.1996.9923030>
- Ramayah, T., Cheah, J., Chuah, F., Ting, H., & Memon, M. A. (2018). *Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 3.0: An Updated Guide and Practical Guide to Statistical Analysis* (2nd ed.). Kuala Lumpur, Malaysia: Pearson.
- Ringle, C. M., Wende, S., & Becker, J.-M. (2022). *SmartPLS 4*. Oststeinbek: SmartPLS. Retrieved from <https://www.smartpls.com>
- Ritter, K. J., Matthews, R. A., Ford, M. T., & Henderson, A. A. (2016). Understanding role stressors and job satisfaction over time using adaptation theory. *Journal of Applied Psychology*, 101(12), 1655-1672. <https://doi.org/10.1037/apl0000146>
- Rosenberg, M. (1965). *Society and the Adolescent Self-Image*. Princeton, NJ: Princeton University Press. <https://doi.org/10.1515/9781400876136>
- Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs: General and Applied*, 80(1), 1-28. <https://doi.org/10.1037/h0092512>
- Saks, A. M. (2006). Antecedents and consequences of employee engagement. *Journal of Managerial Psychology*, 21(7), 600-619. <https://doi.org/10.1108/02683940610690169>
- Samie, F., Riahi, L., & Tabibi, S. J. (2015). The relationship between role clarity and efficiency of employees in management & resource development department of ministry of health and medical education of IR Iran, 2014. *Biosciences, Biotechnology Research Asia*, 12(4), 2803-2812. <https://doi.org/10.13005/bbra/1964>
- Schermuly, C. C., Creon, L., Gerachi, P., Grafmann, C., & Koch, J. (2022). Leadership styles and psychological empowerment: A meta-analysis. *Journal of Leadership & Organizational Studies*, 29(1), 73-95. <https://doi.org/10.1177/15480518211067751>
- Scott, S. G., & Bruce, R. A. (1994). Determinants of innovative behavior: A path model of individual innovation in the workplace. *Academy of Management Journal*, 37(3), 580-607. <https://doi.org/10.2307/256686>
- Seibert, S. E., Silver, S. R., & Randolph, W. A. (2004). Taking empowerment to the next level: A multiple-level

- model of empowerment, performance, and satisfaction. *Academy of Management Journal*, 47(3), 332-349. <https://doi.org/10.2307/20159579>
- Seibert, S. E., Wang, G., & Courtright, S. H. (2011). Antecedents and consequences of psychological and team empowerment in organizations: A meta-analytic review. *Journal of Applied Psychology*, 96(5), 981-1003. <https://doi.org/10.1037/a0023564>
- Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J. H., Ting, H., Vaithilingam, S., & Ringle, C. M. (2019). Predictive model assessment in PLS. *European Journal of Marketing*, 53(11), 2322-2347. <https://doi.org/10.1108/EJM-02-2019-0189>
- Shogren, K. A., & Shaw, L. A. (2016). Employee well-being and psychological empowerment: An empirical study. *Journal of Applied Business Research*, 32(1), 251-266.
- Silen, M., Lepistö, S., & Kuusinen, T. (2019). Factors contributing to nursing students' perceptions of their empowerment. *Nurse Education Today*, 77, 91-96.
- Slatten, T., & Mehmetoglu, M. (2011). Antecedents and effects of engaged frontline employees: A study from the hospitality industry. *Managing Service Quality: An International Journal*, 21(1), 88-107. <https://doi.org/10.1108/09604521111100261>
- Snell, S. A., & Dean, J. W. (1992). Integrated manufacturing and human resource management: A human capital perspective. *Academy of Management Journal*, 35(3), 467-504. <https://doi.org/10.2307/256619>
- Spector, P., & O'Connell, B. J. (1994). The contribution of personality traits, negative affectivity, locus of control, and Type A to the subsequent reports of job stressors and job strains. *Journal of Occupational and Organizational Psychology*, 67(1), 1-18. <https://doi.org/10.1111/j.2044-8325.1994.tb00558.x>
- Spreitzer, G. M. (1995a). Psychological empowerment in the workplace: Dimensions, measurement, and validation. *Academy of Management Journal*, 38(5), 1442-1465. <https://doi.org/10.2307/256865>
- Spreitzer, G. M. (1996). Social structural characteristics of psychological empowerment. *Academy of Management Journal*, 39(2), 483-504. <https://doi.org/10.2307/256865>
- Spreitzer, G. M., Kizilos, M. A., & Nason, S. W. (1997). A dimensional analysis of the relationship between psychological empowerment and effectiveness, satisfaction, and strain. *Journal of Management*, 23(5), 679-704. <https://doi.org/10.1177/014920639702300504>
- Srivastava, A., Bartol, K. M., & Locke, E. A. (2006). Empowering leadership in management teams: Effects on knowledge sharing, efficacy, and performance. *Academy of Management Journal*, 49(6), 1239-1251. <https://doi.org/10.5465/amj.2006.23478718>
- Stander, M. W., & Rothmann, S. (2010). Psychological empowerment, job insecurity, and employee engagement. *South African Journal of Industrial Psychology*, 36(1), 1-8. <https://doi.org/10.4102/sajip.v36i1.849>
- Sullivan, S. E. (1994). The role of delegation in effective management. *Journal of Management*, 20(2), 397-412. <https://doi.org/10.1177/014920639402000207>
- Sweetman, D., & Luthans, F. (2010). The Power of Positive Psychology: Psychological Capital and Work Engagement. In Bakker, A. B., & Leiter, M. P. (Eds.), *Work Engagement: A Handbook of Essential Theory and Research* (pp. 54-68). Psychology Press.
- The Sun Daily. (2023). Robotics and advanced automation pivotal in New Industrial Master Plan transformation. Retrieved from <https://www.mida.gov.my/mida-news/robotics-and-advanced-automation-pivotal-in-new-industrial-master-plan-transformation/>
- Thomas, K. W., & Velthouse, B. A. (1990). Cognitive elements of empowerment: An "interpretive" model of intrinsic task motivation. *Academy of Management Review*, 15(4), 666-681. <https://doi.org/10.5465/amr.1990.4310926>
- Ugwu, F. O., Onyishi, I. E., & Rodríguez-Sánchez, A. M. (2014). Linking organizational trust with employee engagement: The role of psychological empowerment. *Personnel Review*, 43(3), 377-400. <https://doi.org/10.1108/PR-11-2012-0198>
- Ul-Hassan, F. S., Ikramullah, M., Khan, H., & Shah, H. A. (2021). Linking role clarity and organizational commitment of social workers through job involvement and job satisfaction: A test of serial multiple mediation model. *Human Service Organizations: Management, Leadership and Governance*, 1-15. <https://doi.org/10.1080/23303131.2021.1895400>

- Vullingsh, J. T., De Hoogh, A. H. B., Den Hartog, D. N., & Boon, C. (2018). Ethical and passive leadership and their joint relationships with burnout via role clarity and role overload. *Journal of Business Ethics*, 1-17. <https://doi.org/10.1007/s10551-018-4084-y>
- Walumbwa, F. O., Avolio, B. J., Gardner, W. L., Wernsing, T. S., & Peterson, S. J. (2008). Authentic leadership: Development and validation of a theory-based measure. *Journal of Management*, 34(1), 89-126. <https://doi.org/10.1177/0149206307308913>
- Wang, D., Gan, C., & Wu, C. (2016). LMX and employee voice: A moderated mediation model of psychological empowerment and role clarity. *Personnel Review*, 45(4), 605-615. <https://doi.org/10.1108/PR-11-2014-0255>
- Wang, J., & Liu, Y. (2015). Can guanxi HR practices foster employee innovation behavior? The role of career satisfaction and job autonomy. *The International Journal of Human Resource Management*, 26(3), 322-341.
- Whitaker, B. G., Dahling, J. J., & Levy, P. (2007). The development of a feedback environment and role clarity model of job performance. *Journal of Management*, 33(4), 570-591. <https://doi.org/10.1177/0149206306297581>
- Yadav, M., & Anil Kumar. (2017). An Indian outlook on role clarity, organizational citizenship behavior, and gender relationship: Multiple group confirmatory factor analysis (MGCFA) approach. *Jindal Journal of Business Research*, 6(1), 63-75. <https://doi.org/10.1177/2278682117700941>
- Yao, R., Li, S., & Liu, J. (2013). Psychological empowerment, job satisfaction, and organizational commitment among Chinese employees. *Journal of Business Research*, 66(4), 781-787. <https://doi.org/10.1016/j.jbusres.2012.05.014>
- Yilma, B. A., Panetto, H., & Naudet, Y. (2019). A meta-model of cyberphysical-social system: The CPSS paradigm to support human machine collaboration in industry 4.0. *20th IFIP WG 5.5 Working Conference on Virtual Enterprises*, 568(October), 245-258. https://doi.org/10.1007/978-3-030-28464-0_2
- Zhang, X., & Bartol, K. M. (2010). Linking empowering leadership and employee creativity: The influence of psychological empowerment, intrinsic motivation, and creative process engagement. *Academy of Management Journal*, 53(1), 107-128. <https://doi.org/10.5465/amj.2010.48037118>
- Zhang, Y., Fang, Y., Wei, W., & Zhang, M. (2016). Leader-follower congruence in proactive personality and work engagement: The mediating role of leader-member exchange. *Journal of Business and Psychology*, 31(4), 511-523.
- Zhu, J., Yao, J., & Zhang, L. (2019). Linking empowering leadership to innovative behavior in professional learning communities: The role of psychological empowerment and team psychological safety. *Asia Pacific Education Review*, 20(5), 1-15. <https://doi.org/10.1007/s12564-019-09584-2>
- Zimmerman, M. A. (2000). Empowerment theory: Psychological, organizational, and community levels of analysis. In J. Rappaport & E. Seidman (Eds.), *Handbook of Community Psychology* (pp. 43-63). Springer. https://doi.org/10.1007/978-1-4615-4193-6_2

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