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Human Capital 4.0, Employee Green Behavior, and Innovativeness in Indonesian Telecommunications

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Abstract

Background: The rapid advancement of digital technologies under Industry 4.0 has transformed business operations and increased the need for employees to develop relevant knowledge, skills, and attitudes. At the same time, organizations face growing expectations to integrate environmental sustainability into workplace practices and business processes.
Objective: This study examines the relationships among Industry 4.0 human capital competency (HC4.0), employee green behavior (EGB), and individual innovativeness. It also tests whether EGB moderates the relationship between HC4.0 and individual innovativeness.
Methods: A quantitative cross-sectional study was conducted within XT Group, a telecommunications group in Indonesia with more than 20,000 employees. Data were collected through an online questionnaire using random sampling, yielding 347 valid responses. Multiple linear regression was used to examine the direct relationships among HC4.0, EGB, and individual innovativeness and to test the moderating effect of EGB.
Results: the finding shows that individual innovativeness has a significant positive correlation with human capital 4.0 (B = .678, p < .0001) and employee green behavior (B = .172, p = .002). However, this study does not find the same state of correlation for the moderating variable of employee green behavior towards the relationship between human capital 4.0 and individual innovativeness (B = -.096, p = .193).
Conclusion: These findings contribute to the knowledge creation needed for the industry 4.0 era, specifically the human capital competency stream for ICT businesses through human capital development initiatives.

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INTRODUCTION

Industry 4.0 is reshaping business competition globally by integrating digital technologies into production, supply chains, services, and organizational decision-making. (Ustundag & Cevikcan, 2018) and Hu et al. (2026) describe this transformation as the integration of production, supply-chain, and service facilities into value-added networks. Organizations therefore need to adapt their strategies to increasingly digital and technology-intensive operating environments, including the Internet of Things (Muhammad et al., 2022; Roblek et al., 2016). Industry 4.0 also encompasses big data, autonomous robots, augmented reality, additive manufacturing, cloud

computing, cybersecurity, system integration, and simulation (Bal & Erkan, 2019; Ghobakhloo et al., 2023; Rüßmann, 2015), collectively supporting the development of cyber-physical systems (Ghobakhloo et al., 2023; Pereira & Romero, 2017). At the global level, this transformation creates a dual organizational challenge: developing employee capabilities for digital adaptation while maintaining environmentally responsible business practices.

Within Industry 4.0, organizational adaptability increasingly depends on employees who can work effectively with emerging technologies and continuously develop relevant competencies. Prior research indicates that human capital contributes to organizational performance, particularly in innovation-intensive environments that require new combinations of knowledge and skills (Crook, 2011; Li et al., 2021; Singhania & Panda, 2025). Industry 4.0 also changes how organizations structure work and interaction with employees (Al-Suwaidi et al., 2025), while national strategies further shape the pace of adaptation (Al-Suwaidi et al., 2025; Yang & Gu, 2021). These developments make integration and connectivity especially important in telecommunications, which provides the digital infrastructure that supports efficiency and market participation across industries (Forum & Accenture., 2017; Plunkett Research, 2019; Sukma & Yamnill, 2026). Consequently, employees in telecommunications are increasingly expected to understand and utilize technological change in their work (Ejsmont, 2021; Mason et al., 2022).

In Industry 4.0, the human dimension remains critical, and the knowledge, skills, and attitudes (KSA) framework helps explain the competencies required to develop qualified talent (Champa, 2025; Coff, 2002). Knowledge encompasses information, intelligence, and expertise that underpin the understanding and application of technology (Champa, 2025; Hitt et al., 2011). In this context, relevant knowledge includes artificial intelligence, the Internet of Things, big data analytics, cloud computing, and cybersecurity. Skills comprise both hard skills, which are technical and task-specific, and soft skills, which support learning, adaptation, collaboration, and problem solving (Asbari, 2024; Laker & Powell, 2011; Sopa, 2020). Hard skills enable employees to work with Industry 4.0 technologies, whereas soft skills help them manage change and generate new ideas. Soft skills have been shown to relate positively to individual innovativeness (A. Hendarman & Cantner, 2018). Attitudes complement knowledge and skills by shaping employees' openness and responses to technological and organizational change (Lebedeva & Schmidt, 2012; Zahra & Liuchuan, 2022).

Business innovation involves the implementation of novel ideas in tangible products, services, processes, or organizational practices (Edwards-Schachter, 2018; Whitley & Gläser, 2026). Under technological disruption and increasing sustainability demands, innovation therefore needs to become an explicit component of competitive strategy. Industry 4.0 extends innovation across organizational functions by creating opportunities for efficiency, experimentation, and new forms of value creation (Ahmed et al., 2024; Mahmood & Mubarik, 2020). At the employee level, innovativeness is reflected in creativity, support for new ideas, experimentation, and participation in development activities (Mejeryte-Narkeviciene & Paulauskas, 2022; Shum, 2015). It can also be understood as innovation-related work behavior expressed in the workplace (A. Hendarman & Cantner, 2018; Thneibat, 2026). Human resource practices can strengthen such behavior by creating an innovative climate through information sharing, developmental support, and supportive supervision (Bos-Nehles & Veenendaal, 2019; Thneibat, 2026).

As a form of being responsible and doing less harm to the environment, organizations are suggested to start greening their actions within their activities (Hart, 1997; Khan et al., 2022). In the present time, the responsibility to be environmentally conscious for companies has not changed, yet it is becoming more critical, as climate change has become one of the challenges that businesses must strive for in this century (Codina, 2023; Manyika & Tuin, 2020). Relating this phenomenon to the industry 4.0 era, Oláh (2020) and Kopeinig et al. (2024) discovered that the application of the industry 4.0 era is shown to have higher positive causes towards material, energy, information, and high-quality products after analyzing several goals from the Sustainable Development Goals (SDGs). In the context of a business organization environment, Ones & Dilchert (2012) and Kühner et al. (2025) introduced a model for indicating an employee contribution towards environmentally friendly practices in work settings, namely employee

green behavior. Later, a study succeeded in indicating that there are two types of behavior: required behavior, which is driven by job tasks and responsibility, and voluntary behavior, which is driven by personal initiatives and motivation (Abbas et al., 2026; bissing-Olson, 2013; Norton, 2015). However, a study conducted by Sharif et al. (2026) emphasized that the success of lowering ecological footprint heavily depends on effective governance and policy to drive behavioral change.

The relationship of green action in the organizational environment can also be seen in innovation, as green human resource management was a significant predictor of employee in-role green behavior, extra-role green behavior, and green innovative work behavior (Aboramadan, 2022). Ethical leadership also positively affects employee green innovation behavior through the mediation role of green organizational identity (Chen et al., 2022; Liu & Zhao, 2019). Green innovation, which comprises green product and green process innovation cultures, also improves a company's green performance (Muisyo & Qin, 2021; Yousaf et al., 2025). Besides, green creativity is also one of the important predictors of green innovation and environmental performance (Malik et al., 2021; Rana & Arya, 2024).

Organizations are required to respond simultaneously to rapid technological change and environmental sustainability pressures (Erol, 2016; Kumar et al., 2026). For telecommunications companies, this challenge includes developing advanced digital infrastructure while improving the sustainability of operations and services. Research indicates that ICT and Industry 4.0 technologies can strengthen knowledge-related performance, positioning ICT firms as important actors in digital transformation (Bettiol et al., 2021). Digitalization may also support environmental sustainability when it is accompanied by appropriate organizational practices (Charfeddine & Umlai, 2023). XT Group, a state-owned telecommunications group in Indonesia, has publicly emphasized ESG-oriented initiatives and long-term value creation through innovative services. In this context, the present study assesses employees' individual innovativeness in the Industry 4.0 era and examines how HC4.0 competency and employee green behavior relate to that innovativeness.

Hendarman & Cantner (2018) examined the relationship between employee skills and individual innovativeness in a general organizational context. However, limited evidence explains how a broader Industry 4.0 human capital competency framework relates to individual innovativeness when environmentally responsible workplace behavior is considered simultaneously. This study addresses that gap by testing HC4.0 and EGB simultaneously and by examining EGB as a potential moderator of the HC4.0-individual innovativeness relationship in an Indonesian telecommunications context. The novelty of this study lies in integrating HC4.0 competency and EGB within one empirical model and testing EGB not only as a direct predictor of individual innovativeness but also as a boundary condition that may alter the HC4.0-innovativeness relationship in the Indonesian telecommunications sector.

METHOD

The study used a quantitative cross-sectional design with a deductive approach. The deductive logic began with established concepts and hypotheses and tested their relationships using empirical survey data (Bougie & Sekaran, 2025; Saunders et al., 2012). Data were collected in 2024 through an online questionnaire administered over a two-month period across three firms within XT Group. The instrument used a five-point Likert scale ranging from 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, to 5 = Strongly Agree. Multiple linear regression (MLR) was used to examine the relationships between Industry 4.0 human capital competency, employee green behavior, and individual innovativeness, including the interaction term used to test moderation. All analyses were conducted using IBM SPSS Statistics version 26. This specification is explanatory rather than purely exploratory because the study tests theory-derived hypotheses concerning the direction and significance of relationships among predefined constructs. The cross-sectional design was selected to capture employees' perceptions and behaviors at a defined point in time across the three firms. A five-point Likert scale was used because HC4.0, EGB, and individual innovativeness are latent constructs operationalized through multiple attitudinal and behavioral statements; ordered agreement categories allow respondents

to express the intensity of their perceptions while supporting composite-scale and regression analysis.

This study examines the relationship between Human Capital 4.0 (HC4.0) and Individual Innovativeness, with Employee Green Behavior (EGB) positioned as both a predictor and a moderating variable. HC4.0 represents employees' knowledge, hard skills, soft skills, and attitudes relevant to Industry 4.0, while Individual Innovativeness reflects employees' technical and non-technical innovative activities. EGB represents employees' required and voluntary environmentally responsible behaviors in the workplace. Based on the conceptual framework presented in Figure 1, three hypotheses were formulated: The conceptual foundation combines the knowledge-skills-attitudes perspective used to explain human capital competency (Champa, 2025; Coff, 2002; Hitt et al., 2011), the employee green behavior framework distinguishing required and voluntary pro-environmental behavior (Kühner et al., 2025; Norton, 2015; Ones & Dilchert, 2012), and the individual-innovativeness perspective linking employee capabilities with innovation-related work behavior (A. Hendarman & Cantner, 2018).

The hypotheses are: H1: Human Capital 4.0 has a positive and significant relationship with Individual Innovativeness; H2: Employee Green Behavior has a positive and significant relationship with Individual Innovativeness; and H3: Employee Green Behavior moderates the relationship between Human Capital 4.0 and Individual Innovativeness. H1 is derived from evidence that employee skills and competencies support individual innovativeness (A. Hendarman & Cantner, 2018). H2 reflects prior evidence connecting environmentally oriented employee and HR practices with green and innovative work behavior (Aboramadan, 2022; Shu et al., 2016). H3 extends these direct relationships by testing whether environmentally responsible behavior changes the strength of the association between HC4.0 competency and individual innovativeness.

Table 1
Questionnaire Design

Construct	Factor	Item	Statement	Source
Human Capital 4.0	Knowled	K1	My understanding about industry 4.0 era is already sufficient or adequate	(Bal & Erkan, Gilchrist, 2016;
		K2	I am familiar with the technologies that support Industry 4.0.	Hendarman et 2020; A.
		K3	I am aware about the terminology of automation	ırman & stu, 2019;
		K4	I know the concept and ability of automation	pudi & Lenka, Rüßmann,
		K5	I am aware of Big Data and its impact to the prospect of development of industrialization	
		K6	I am aware of Augmented Reality technology and its impact to the prospect of development of industrialization	
		K7	I am aware of Cloud Computing technology and its impact to the prospect of development of industrialization	
		K8	I am aware of Cybersecurity technology and its impact to the prospect of development of industrialization	
		K9	I am aware of Internet of Things technology and its impact to the prospect of development of industrialization	
		K10	I am aware of Internet of System Integration (Vertical and Horizontal)	

Construct	Factor	Item	Statement	Source
			technology and its impact to the prospect of development of industrialization	
		K11	I am aware of Simulation process and its impact to a particular project or product (something that supports the value of development)	
	HardSkill	H1	I can execute business activity such as market research and product marketing or production process or employee training and recruiting	(A. F. Hendarman et al., 2020) (Hendarman & Pangestu, 2019) (A. Hendarman & Pangestu, 2019; Kim, 2018; Marlapudi & Lenka, 2025; Oktari et al., 2023; Picincu, 2019; Pidun et al., 2019; Rao, 2005; Shafrir & Kenett, 2010; Sousa & Rocha, 2019)
		H2	For every new information, I will give a thought or process the message beforehand from various aspect	
		H3	I can handle any issues or problem by analyzing the data or create a prototype to be more understandable	
		H4	I understand the relationship between my company and other companies from the market's point of view because of the present integrated data and easy access	
		H5	I am always focus with one problem and think from the general/most important part point-of-view fast and easily because there are integrated data that is related to the problem	
		H6	I can manage my information/knowledge and collected data easily by saving them through a saved application/data base owned by the company or my team	
		H7	I am motivated to share my knowledge and experience as well as teaching new things to colleagues either from both or outside my division	
		H8	I have prepared myself to overcome any challenges to apply/implement industry 4.0	
	SoftSkill	S1	I have a lot of connection outside my division	(Costanza, 2016; Hayes, 2005; A. Hendarman & Cantner, 2018; A. F. Hendarman et al., 2020; Marlapudi & Lenka, 2025; Sousa & Rocha, 2019; Vaari, 2015)
		S2	Whenever changes occur, I am ready to adapt and take appropriate risks.	
		S3	I am able to adapt fast with new environment that uses new technology	
		S4	Every time there is a job, I always think the impact from the task's outcome for a certain period	
		S5	I am responsible to implement industry 4.0 although this is new to me	
		S6	I am able to organize/manage any resources in my company to fulfill any opportunities for industry 4.0 implementation	

Construct	Factor	Item	Statement	Source
		S7	I am able to innovate (the process of developing a particular existing product or knowledge) and develop within industry 4.0 through maximizing the usage of database	
		S8	I am able to accept my new company culture when implementing industry 4.0	
		S9	I am offered with training and conference opportunities about industry 4.0	
	Attitude	A1	I am ready and motivated to overcome industry 4.0 era	(Acosta-Enriquez et al., 2024; A. F. Hendarman et al., 2020; A. Hendarman & Pangestu, 2019; Ostrom, 1969)
		A2	After knowing the technology development and industry 4.0 era, I tried to deepen my knowledge towards this aspect	
		A3	I am prepared to join activities (workshop, training) that can bring more insight towards the newest technology to be implemented in my workplace	
Employee Green Behavior	Required Voluntary	BR1	The company made me to be aware of my actions for environmental conservation	(Norton, 2015; Smith, 2012; Weerakkody et al., 2022;Weerarathna et al., 2017)
		BR2	I am active to follow any rules or policies that is related to environmental conservation	
		BR3	The company made policies for me to do environmentally friendly practices in the workplace	
		BR4	I am actively practicing green practices in my company's environment (office, garden, parking lot, etc)	
	Voluntary Behavior	BV1	Personally, I believed that eco-friendly practices are a method to save the environment	
		BV2	I am used to do eco-friendly actions in daily routines	
		BV3	In my working site/office, I am always careful to use the facility which can affect the environment	
	Business Context	BS1	I believed that if a company acts responsible towards environment, the impact afterwards will affect the business (company) productivity in the context of financial, competitiveness and reputation	
		BS2	I have initiated to the company to be economic and wise in using existing resources	
	Environ-mental Context	BS3	I believed that if a company acts responsible towards environment, the impact afterwards will affect the environmental sustainability and society	
		BS4	To me, in general my company have perform optimally to conserve or responsible to the environment and its surroundings	

Construct	Factor	Item	Statement	Source
Individual Innovativeness	Technical	IT1	I have made improvement to my work process in workplace	(Fan, 2026; A. Hendarman & Pangestu, 2019; Van Oort et al., 2009)
		IT2	I have a direct role to create improvements in production sector or product development in my work task	
		IT3	I have been involved to participate in creating development towards a particular product or through company project	
	Non Technical	INT1	Related with innovation at work, I developed and nurture sense of cooperation with other party (employee, customer, society and other stakeholder)	
		INT2	I have been involved in company's development planning	
		INT3	I have been involved in building management development	

The operational population comprised employees of three telecommunications firms within XT Group in Indonesia. These firms were selected because their activities were closely related to information and communication technology and were directly exposed to Industry 4.0 transformation. All employees were eligible to participate because innovation was relevant across organizational functions. Random sampling was employed. According to the company's 2023 annual report, the group employed approximately 20,000 people. A total of 347 completed responses were analyzed, corresponding to an estimated sampling error of approximately 5.22% under simple random sampling assumptions. Simple random sampling was considered appropriate because all employees within the defined organizational population met the eligibility criterion, and the study sought to minimize systematic selection bias based on job category or management level (Bougie & Sekaran, 2025; Saunders et al., 2012). The 347 observations represented the total number of usable responses obtained rather than a post hoc quota. Based on an approximate population of 20,000 employees, a 95% confidence level, maximum population variability (p = .50), and a finite population correction, a sample size of 347 corresponded to an estimated sampling error of approximately 5.2%, consistent with the reported value of 5.22%.

Table 2
Summary of respondent profile

Descriptive Statistics					
	n	Minimum	Maximum	Mean	Std. Deviation
Sex (Female)	347	.00	1.00	.2738	.44654
GenX	347	.00	1.00	.6311	.48320
GenY	347	.00	1.00	.3573	.47991
GenZ	347	.00	1.00	.0115	.10690
LowMgmt	347	.00	1.00	.4697	.49980
MiddleMgmt	347	.00	1.00	.5216	.50025
TopMgmt	347	.00	1.00	.0086	.09271
SeniorHigh	347	.00	1.00	.1124	.31630
Diploma	347	.00	1.00	.1153	.31981
Bachelor	347	.00	1.00	.5187	.50037
Master	347	.00	1.00	.2507	.43405
Doctoral	347	.00	1.00	.0029	.05368
Valid N (listwise)	347				

As shown in Table 2, the values in the mean column represented the proportions of respondents in each demographic category. Male respondents accounted for 73% of the sample, while female respondents accounted for 27%. Generation X represented the largest group, at 63% (232 respondents), followed by Generation Y (millennials), at 35%, and Generation Z, at 1%. Regarding educational background, bachelor's degree holders accounted for 51% of respondents, master's degree holders for 25%, diploma holders for 11%, senior high school graduates for 11%, and doctoral degree holders for less than 1%. In terms of management level, middle management represented approximately 50% of respondents, followed by lower management at 47%, while top management accounted for less than 1%.

For the regression coding presented in the descriptive statistics table, Generation X, Generation Y, and Generation Z were represented by mutually exclusive binary indicators (1 = membership in the indicated cohort; 0 = otherwise), explaining the minimum and maximum values of 0 and 1, respectively. The available analyzed dataset identified cohort membership using these labels but did not report the underlying birth-year cutoffs. Therefore, no additional age boundaries were inferred in this manuscript. The final validity assessment using principal component analysis (PCA) is presented in the table 3.

Table 3
KMO and bartlett's test for sampling adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.967
Bartlett's Test of Sphericity	Approx. Chi-Square	15462.025
	df	1176
	Sig.	.000

The principal component analysis results, together with the KMO and Bartlett's tests, supported the adequacy of the measurement data. All reported component coefficients exceeded 0.300, indicating that the retained indicators met the loading criterion established for this study. The KMO measure also indicated adequate sampling suitability, while Bartlett's test was statistically significant. Reliability was subsequently assessed using Cronbach's alpha. All reported coefficients exceeded 0.70, supporting the internal consistency of the measured factors.

PCA was used as a preliminary measurement-screening procedure to examine whether the observed items exhibited an adequate common structure before the composite variables were entered into the regression models. The KMO statistic evaluates sampling adequacy for component or factor extraction, whereas Bartlett's test evaluates whether the inter-item correlation matrix contains sufficient correlations to support such analysis. Cronbach's alpha subsequently assesses internal consistency (J. F. Hair et al., 2019; J. Hair & Sabol, 2025). The very high KMO value (.967), statistically significant Bartlett's test ($p < .001$), retained component coefficients exceeding .300, and Cronbach's alpha coefficients exceeding .70 collectively supported the suitability of the measurement data for subsequent regression analysis.

RESULTS AND DISCUSSION

Model 1 estimates the baseline multiple linear regression equation for the direct relationships among HC4.0, EGB, and individual innovativeness. Model 2 extends this specification by adding the HC4.0 x EGB interaction term to test the proposed moderating effect.

Model 1. The regression results show that both HC4.0 and EGB have positive and statistically significant relationships with individual innovativeness. HC4.0 was significant at $p < .001$, while EGB was significant at the 5% level. These results support H1 and H2, indicating that higher HC4.0 competency and stronger employee green behavior are associated with higher individual innovativeness. Holding the other predictor constant, the unstandardized coefficient for HC4.0 (B = .678, SE = .052, beta = .615, $p < .001$) indicates a comparatively strong positive association with individual innovativeness. EGB also shows a positive independent association (B = .172, SE = .056, beta = .144, p = .002), although its standardized contribution is smaller than that of HC4.0. Thus, statistical significance in Model 1 indicates that both predictors explain unique variation in individual innovativeness within the observed sample.

Table 4
Model 1 regression result

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.596	.207		2.884	.004
	HC4.0	.678	.052	.615	13.042	.000
	EGB	.172	.056	.144	3.067	.002

a. Dependent Variable: Innov
****)99% confidence interval, **)95% confidence interval, *)90% confidence interval*

Model 2. This model tests H3 by introducing the HC4.0 x EGB interaction term. HC4.0 and EGB remained statistically significant, whereas the interaction term was not statistically significant. Accordingly, H3 was not supported, indicating that EGB did not significantly moderate the relationship between HC4.0 and individual innovativeness in this sample. The negative interaction coefficient reported for HC4.0 x EGB (B = -.096, p = .193) is not statistically distinguishable from zero at conventional significance levels. Consequently, the data do not support the proposition that EGB strengthens or weakens the effect of HC4.0 on innovativeness; instead, the two constructs operate primarily as separate direct predictors in this model.

Table 5
Model 2 regression result

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std Error	Beta	t	Sig.
2	(Constant)	-1.025	1.259		-.814	.416
	HC4.0	1.102***	.329	.999	3.348	.001
	EGB	.543*	.290	.456	1.875	.062
	HC4.0xEGB	-.096	.074	-.624	-1.305	.193

a. Dependent Variable: Innov
****)99% confidence interval, **)95% confidence interval, *)90% confidence interval*

The subsequent analysis evaluates the robustness of the baseline specification. Table 6 presents Model 3, which adds demographic and organizational control variables to Model 1.

Table 6
Model 3 regression result

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
3	(Constant)	.506	.593		.853	.394
	HC4.0	.713***	.056	.646	12.710	.000
	EGB	.116**	.061	.098	1.902	.058
	Sex	.043	.058	.030	.736	.462
	GenY	-.097*	.057	-.073	-1.722	.086
	GenZ	-.077	.230	-.013	-.333	.739
	LowMgmt	-.138	.268	-.107	-.515	.607
	MiddleMgmt	-.110	.266	-.085	-.412	.680
	SeniorHigh	.499	.459	.246	1.086	.278
	Diploma	.385	.460	.192	.837	.403
	Bachelor	.290	.455	.226	.638	.524

Coefficients[a]					
Master	.351	.457	.237	.767	.443

a. Dependent Variable: Innov
***)99% confidence interval, **)95% confidence interval, *)90% confidence interval

Model 3. After the control variables were added, HC4.0 and EGB remained statistically significant and positively associated with individual innovativeness. Most control variables were not statistically significant. Generation Y was the exception, showing a statistically significant negative relationship with individual innovativeness relative to the reference category used in the model.

Table 7
Model 4 regression result

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
4	(Constant)	-1.256	1.351		-.929	.353
	HC4.0	1.196***	.338	1.085	3.538	.000
	EGB	.533*	.294	.447	1.814	.071
	HC4.0xEGB	-.109	.075	-.707	-1.450	.148
	Sex	.041	.058	.029	.709	.479
	GenY	-.104*	.057	-.078	-1.834	.068
	GenZ	-.078	.230	-.013	-.340	.734
	LowMgmt	-.178	.269	-.139	-.663	.508
	MiddleMgmt	-.152	.267	-.118	-.567	.571
	SeniorHigh	.469	.459	.231	1.021	.308
	Diploma	.372	.459	.185	.810	.418
	Bachelor	.264	.455	.206	.581	.561
	Master	.318	.457	.215	.696	.487

a. Dependent Variable: Innov
***)99% confidence interval, **)95% confidence interval, *)90% confidence interval

Model 4. This model provides a robustness check for Model 2 by adding the same control variables. HC4.0 and EGB remained positively and statistically significantly associated with individual innovativeness, while Generation Y retained a significant negative coefficient. The HC4.0 x EGB interaction term remained statistically non-significant, reinforcing the conclusion that EGB did not moderate the HC4.0-individual innovativeness relationship.

Regression Model Evaluation and Discussion

Table 8 summarizes the explanatory performance of the four regression models. Model 1 includes HC4.0 and EGB as predictors of individual innovativeness. Model 2 adds the HC4.0 x EGB interaction term. Models 3 and 4 extend the first two specifications by including control variables for sex, birth generation, management position, and educational background.

Table 8
Overall model summary

Model Summary				
	Model			
	1	2	3	4
R	.710[a]	.711[b]	.721[c]	.723[d]
R-square	.504	.506	.520	.523
Adjusted R-square	.501	.502	.504	.506
Std Error of the Estimate	.45355	.45309	.45198	.45124

Predictors: (Constant), EGB, HC4.0

Model Summary
Predictors: (Constant), EGB, HC4.0, HC4.0
Predictors: (Constant), Master, GenZ, EGB, Diploma, MiddleMgmt, Sex, SeniorHigh, GenY, HC4.0, LowMgmt, Bachelor
Predictors: (Constant), Master, HC4.0xEGB, GenZ, Diploma, MiddleMgmt, Sex, GenY, SeniorHigh, EGB, LowMgmt, HC4.0, Bachelor

Across the four specifications, adjusted R-squared increased modestly as additional terms were introduced. The changes were 0.002 from Model 1 to Model 2, 0.014 from Model 2 to Model 3, and 0.003 from Model 3 to Model 4. These increments indicate only limited gains in explanatory power from the interaction and control variables, while the substantive contribution of HC4.0 and EGB remained comparatively stable.

The findings are consistent with A. Hendarman & Cantner (2018), who reported that both soft and hard skills are positively related to individual innovativeness. Extending that perspective, the present study shows that a broader HC4.0 competency construct - comprising knowledge, hard skills, soft skills, and attitudes - is positively associated with innovativeness in an Industry 4.0 context. EGB also shows a positive relationship with individual innovativeness, which is consistent with evidence that environmentally oriented management and behavior can support innovation (Shu et al., 2016). However, the non-significant interaction indicates that environmentally responsible behavior does not strengthen or weaken the HC4.0-innovativeness relationship in a statistically detectable way in this sample. The significant HC4.0 result therefore extends A. Hendarman & Cantner (2018) from general hard- and soft-skill effects to a broader competency configuration that also incorporates knowledge and attitudes relevant to Industry 4.0. The positive EGB coefficient is also compatible with Aboramadan (2022), who links environmentally oriented HR practices and employee green behavior, and with Shu et al. (2016), who show that green management can support product innovation. In contrast, the unsupported moderation hypothesis suggests that pro-environmental behavior does not automatically amplify the innovation value of digital-era competencies. One plausible interpretation is that HC4.0 and EGB represent complementary but distinct employee resources: competency supports the capacity to generate and implement ideas, whereas green behavior reflects the environmental orientation of workplace action. This distinction also explains why both direct effects remain significant while their interaction does not.

CONCLUSION

This study contributes to understanding how employee capabilities and environmentally responsible work behavior relate to individual innovativeness in an Industry 4.0 setting. HC4.0 competency and EGB were each positively and significantly associated with individual innovativeness. By contrast, the HC4.0 x EGB interaction was not statistically significant, indicating that EGB did not moderate the relationship between HC4.0 and individual innovativeness in the observed sample. The findings therefore suggest that HC4.0 and EGB contribute independently to individual innovativeness, with HC4.0 showing the larger contribution in the estimated models.

The findings should be interpreted within the study's limitations. Data were obtained from one telecommunications group and collected using a cross-sectional design, which limits generalization across industries and does not establish temporal causality. Future studies should replicate and extend the model across different industries, organization sizes, and public or private sector settings, and should consider longitudinal designs to examine how HC4.0, employee green behavior, and individual innovativeness evolve over time. Future research should also test multi-wave or longitudinal models, compare telecommunications with manufacturing and service industries, examine organizational-level boundary conditions such as green climate and innovation climate, and evaluate potential mediators including knowledge sharing, work engagement, and psychological empowerment. Replication with probability samples drawn from multiple independent organizations would further strengthen external validity and allow the stability of the non-significant moderation effect to be assessed across institutional settings.

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AUTHOR CONTRIBUTION STATEMENT

Achmad Fajar Hendarman: Conceptualization, research design, methodology, data processing, formal analysis, interpretation of results, writing - original draft, and overall quality control. Dhanawa Rylla Insani: Data collection, data processing, and writing - review and editing. Bulan Chandra Pramesti: Data processing, research administration, and writing - review and editing. Lutfita Astifani Rundana: Literature review and writing - review and editing. All authors reviewed and approved the final manuscript.

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