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Code green: ethical leadership's role in reconciling AI-induced job insecurity with pro-environmental behavior in the digital workplace

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The current research investigates the complex interplay between artificial intelligence (AI)-induced job insecurity, psychological contract breach (PCB), pro-environmental behavior at work (PEBW), and ethical leadership in the context of organizational sustainability. As AI technologies increasingly permeate the workplace, understanding their impact on employee attitudes and behaviors becomes crucial for maintaining organizational effectiveness and environmental responsibility. Drawing on several theories, we developed and tested a moderated mediation model using a three-wave time-lagged design with 391 employees from various South Korean corporations. Our findings reveal that AI-induced job insecurity does not directly affect PEBW, but rather operates through the mediating mechanism of PCB. Specifically, AI-induced job insecurity positively influences PCB, which in turn negatively affects PEBW. Moreover, ethical leadership emerges as a significant moderator, mitigating the positive association between AI-induced job insecurity and PCB. This study uniquely contributes to the literature by integrating AI-induced job insecurity into the organizational sustainability framework, offering novel insights into how technological advancements influence employee pro-environmental behaviors. Our findings extend the understanding of the Context-Attitudes-Behavior framework in the digital age, bridging the gap between technological disruption literature and environmental sustainability research. These results provide practical implications for organizations striving to balance technological innovation with employee well-being and environmental responsibility, offering strategies for maintaining pro-environmental behaviors amidst AI-induced uncertainties. This paper contributes to the growing literature on AI at work and offers insights for organizations navigating the challenges of technological advancement while promoting environmental sustainability.

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Introduction

The escalating environmental challenges confronting our planet have propelled employee pro-environmental behavior at work (PEBW) to the forefront of organizational sustainability efforts. As businesses grapple with their ecological footprint, PEBW has emerged as a critical factor in mitigating environmental degradation and fostering sustainable practices within organizational contexts (Norton et al., 2015; Yang et al., 2023). These voluntary actions, encompassing a spectrum of behaviors from energy conservation and waste reduction to eco-innovation and environmental stewardship, collectively contribute to an organization's environmental performance and, by extension, to global sustainability initiatives (Ones & Dilchert, 2012). The significance of PEBW extends beyond mere corporate social responsibility; it represents a fundamental shift in how organizations approach environmental sustainability, recognizing that employee engagement is pivotal to achieving meaningful ecological outcomes (Bai et al., 2024). In an era where environmental risks pose existential threats to businesses and society at large, understanding and promoting PEBW has transitioned from a peripheral concern to a strategic imperative for organizational resilience and long-term viability.

The recognition of PEBW's critical role has catalyzed extensive scholarly inquiry into its antecedents, aiming to unravel the complex web of factors that drive or inhibit these pro-environmental behaviors at work. This burgeoning body of research has illuminated a diverse array of influences, operating at multiple levels of analysis. At the individual level, studies have identified environmental attitudes, personal values, and environmental knowledge as key predictors of PEBW (Kim et al., 2017; Zacher et al., 2023). Organizational elements, including green organizational culture, leadership support for environmental initiatives, and the presence of environmental management systems, have been proven to significantly shape members' propensity to engage in pro-environmental actions (Paillé et al., 2013; Tian et al., 2020; Zacher et al., 2023).

Despite the growing body of literature on PEBW antecedents, several critical research gaps persist. Firstly, there is a notable paucity of works investigating the impact of artificial intelligence (AI)-related variables on PEBW (Zacher et al., 2023). In an era where AI is rapidly transforming the business landscape, understanding its implications for employee behaviors, including PEBW, is paramount. Particularly, the concept of AI-induced job insecurity has become a prominent issue in contemporary work environments (Brougham & Haar, 2020). While existing literature has explored the impact of job insecurity on various work outcomes (Lee et al., 2018), the specific effects of AI-induced job insecurity on pro-environmental behaviors remain unexplored. This gap is particularly significant given the dual challenges organizations face in managing technological disruption and environmental sustainability. The potential link between AI-induced job insecurity and PEBW can be theoretically grounded in several perspectives. The Conservation of Resources theory (Hobfoll et al., (2018)) suggests that employees facing job insecurity may reduce engagement in discretionary behaviors like PEBW. Social Exchange Theory (Cropanzano & Mitchell, 2005) posits that AI-induced job insecurity might be perceived as a breach of the implicit social contract, potentially diminishing employees' willingness to engage in extra-role behaviors.

Secondly, while studies have explored various antecedents of PEBW, there is a lack of research delving into the underlying mechanisms and contextual variables that explain the AI-induced job insecurity-PEBW link (Zacher et al., 2023). Understanding these mediating and moderating mechanisms is crucial for cultivating a refined comprehension of how technological changes affect employee behaviors. Specifically, the role of employee

attitudes towards their psychological contract with the organization, such as perceptions of psychological contract breach (PCB), may be pivotal in elucidating the AI-induced job insecurity-PEBW link.

Thirdly, the buffering role of ethical leadership in the context of PEBW, particularly in relation to AI-induced challenges, remains underexplored. Ethical leadership, which refers to the practice of adhering to morally correct behavior and encouraging others to do the same (Brown & Treviño, 2006), may weaken the potential negative impacts of AI-induced job insecurity on employee attitudes and behaviors. In an environmentally precarious world, where organizational actions have far-reaching ecological consequences, the importance of ethical leadership in guiding sustainable practices cannot be overstated.

To address these research gaps and contribute to a more comprehensive understanding of PEBW in the context of technological change, this study aims to investigate the following research questions:

"To what extent does AI-induced job insecurity influence PEBW, and how is this relationship mediated by PCB and moderated by ethical leadership?"

This integrated research question encompasses our investigation into the intricate interaction between AI-induced job insecurity and PEBW, examining both the mediating role of psychological contract breach and the moderating influence of ethical leadership. By addressing this question, we aim to contribute to a more comprehensive understanding of the complex interplay between technological change, employee perceptions, leadership, and pro-environmental behaviors in contemporary organizations.

This study uniquely contributes to the literature by integrating three distinct research streams: AI-induced job insecurity, psychological contract theory, and pro-environmental behavior at work. While previous studies have examined these concepts separately (e.g., Brougham & Haar, 2018; Paillé & Raineri, 2015; Zacher et al., 2023), our research is the first to explore their interconnections in the context of organizational sustainability. By investigating the mediating role of psychological contract breach and the moderating effect of ethical leadership, we offer a meaningful knowledge of how technological advancements affect members' behaviors in an environmentally critical era.

To be specific, to deal with the research gaps, this study proposes a comprehensive model that examines the AI-induced job insecurity-PEBW link, with PCB as a mediator and ethical leadership as a moderating factor. Our theoretical framework integrates three complementary theories that together provide a comprehensive foundation for understanding the relationships in our model. First, Social Exchange Theory (Cropanzano & Mitchell, 2005) illuminates how psychological contract breach mediates the relationship between AI-induced job insecurity and pro-environmental behaviors through the lens of reciprocity and social exchange relationships. Second, the Context-Attitudes-Behavior framework (Guagnano et al., 1995) provides an overarching structure that explains how organizational context (AI implementation) shapes employee attitudes (psychological contract perceptions) and ultimately influences their behaviors (PEBW). Third, Social Information Processing Theory (Salancik & Pfeffer, 1978) explains how employees interpret and respond to AI-related changes in their work environment, particularly highlighting the role of ethical leadership in shaping these interpretations. Together, these theories provide a comprehensive theoretical foundation that enables us to examine the multifaceted impacts of AI on employee behaviors, particularly in the context of environmental sustainability. By integrating these perspectives, we can offer a more nuanced knowledge of the complex

interaction among technological change, members' perceptions, leadership, and pro-environmental behaviors.

This study's relevance extends beyond addressing an understudied area in the literature. By examining the interplay between AI-induced job insecurity, psychological contract breach, and pro-environmental behavior at work, our research offers several significant contributions.

First, our study connects two critical areas of contemporary organizational research: the management of technological change and the promotion of pro-environmental behaviors. By examining how AI adoption influences environmental behaviors, we contribute to a more holistic understanding of organizational sustainability that considers both technological and human factors.

Second, as governments and organizations worldwide grapple with the dual challenges of technological disruption and environmental sustainability, our research can inform the development of policies that address both issues simultaneously. Our findings may help in crafting regulations or organizational policies that mitigate the potential negative impacts of AI on employee behaviors while fostering a culture of environmental responsibility.

Third, by examining the moderating role of ethical leadership in the context of AI-induced job insecurity and pro-environmental behaviors, this paper may contribute to the literature on responsible leadership in times of technological change. This can help in developing leadership training programs that are better equipped to handle the ethical challenges posed by AI implementation.

Fourth, our study integrates insights from multiple theoretical perspectives, including the conservation of resources (COR) theory, the Social Exchange Theory (SET), the Psychological Contract Theory (PCT), the Social Information Processing Theory (SIPT), and Context-Attitudes-Behavior framework, Social Exchange Theory, and Uncertainty Management Theory. This integration provides a more comprehensive understanding of how technological changes in the workplace influence employee attitudes and behaviors, particularly in the context of environmental sustainability. By doing so, we contribute to the development of a more nuanced theoretical framework for understanding the complex dynamics of organizational sustainability in the age of AI.

Finally, as organizations increasingly adopt AI technologies while simultaneously striving to enhance their environmental performance, our research offers valuable insights for managers and policymakers. Understanding how AI-induced job insecurity affects pro-environmental behaviors can help organizations develop more effective strategies for managing technological transitions while maintaining or improving their sustainability initiatives.

By advancing theoretical understanding and integrating multiple perspectives, this research enriches current knowledge of the complex interplay between technological change, employee perceptions, leadership, and pro-environmental behaviors. Specifically, our study extends existing theories by examining how AI-induced workplace changes affect employee environmental behaviors through psychological mechanisms, while considering the role of ethical leadership. This integration of technological advancement literature with environmental sustainability research offers novel insights into organizational behavior in the digital age.

Theory and hypotheses

AI-induced job insecurity and its organizational impact. We suggest that AI-induced job insecurity may result in a decrease in

employee PEBW. AI-induced job insecurity is an emerging concept in organizational psychology and management research, reflecting the growing concerns about the impact of AI technologies on employment stability and job roles. The phenomenon extends traditional notions of job insecurity by incorporating the specific threats posed by AI and automation to various occupations and industries. AI-induced job insecurity can be conceptualized as employees' perceptions of potential job loss or significant job changes due to the implementation or advancement of AI technologies in their workplace or industry (Brougham & Haar, 2018). This form of insecurity is characterized by unique features that distinguish it from general job insecurity, such as the rapid pace of technological change and the potentially wide-ranging impact across diverse job categories (Frey & Osborne, 2017; Nam, 2019). Recent research has identified several factors contributing to AI-induced job insecurity. Technological advancements in machine learning, natural language processing, and robotics have expanded the capabilities of AI systems, leading to increased automation potential across various job roles (Frank et al., 2019). Additionally, organizational strategies focused on digital transformation and cost reduction through AI implementation have heightened employees' awareness of potential job displacement (Shrestha et al., 2019). The consequences of AI-induced job insecurity extend beyond those associated with general job insecurity (Bazzoli & Probst, 2023; Muñoz Medina et al., 2023; Shoss et al., 2023). Previous works have shown that it can lead to increased technostress, reduced job satisfaction, and diminished organizational commitment (Brougham & Haar, 2018; Califf et al., 2020; Shoss et al., 2023).

Pro-environmental behavior at work (PEBW): definition and importance. PEBW is an emerging concept in organizational and environmental psychology research, focusing on employees' voluntary actions that contribute to environmental sustainability within the workplace context (Zhang et al., 2024). This topic has garnered considerable attention in recent years, mostly due to the growing focus on corporate sustainability and the acknowledgement of employees' contribution to accomplishing environmental objectives (Tu et al., 2023; Zacher et al., 2023). PEBW encompasses a wide range of actions that employees undertake to diminish the environmental influences of their job-related activities and promote ecological sustainability within their organizations (Bai et al., 2024; Kim et al., 2017). These behaviors can include energy conservation, waste reduction, recycling, sustainable commuting, and advocating for environmentally friendly policies and practices (Boiral et al., 2015; Nie et al., 2023). The consequences of PEBW extend beyond environmental benefits. Research has shown that engaging in PEBW is associated with increased job satisfaction, enhanced organizational commitment, and enhanced employee well-being (Lamm et al., 2013; Yuriev et al., 2018; Zacher et al., 2023). Moreover, organizations that successfully promote PEBW often experience reputational benefits and improved stakeholder relations (Raineri & Paillé, 2016; Zacher et al., 2023).

AI-induced job insecurity and employee PEBW. In line with our research objective to understand the impact of AI-induced job insecurity on pro-environmental behaviors, our first hypothesis examines the direct relationship between these two constructs. The integration of AI at work has introduced a novel form of job insecurity, termed AI-induced job insecurity, which may significantly impact employee behaviors, including PEBW. This research investigates the association between AI-induced job insecurity and PEBW through the lens of the social exchange theory.

The social exchange theory (SET) further elucidates the potential negative relationship between AI-induced job insecurity and PEBW by focusing on the reciprocal nature of employee-organization relationships. SET suggests that employment relationships are based on a series of interdependent exchanges, with the expectation of reciprocity governing these interactions (Cropanzano & Mitchell, 2005). When organizations implement AI technologies in a manner that creates job insecurity, members would regard this as a violation of the implicit social contract between them and their employer. This perceived imbalance in the exchange relationship can lead to a reduction in employees' felt obligation to reciprocate with positive discretionary behaviors. Recent work by Paillé et al. (2023) supports this notion, demonstrating that perceived organizational support significantly influences employees' engagement in pro-environmental behaviors.

Hypothesis 1: AI-induced job insecurity is negatively associated with PEBW.

AI-induced job insecurity and PCB

The role of psychological contract breach in workplace behaviors. We suggest that AI-induced job insecurity may augment PCB. PCB is a significant concept, focusing on the perceived violation of implicit agreements between employees and their employers (Kim & Kim, 2024; Zhong et al., 2023). This concept has gained substantial attention because of its profound effect on members' attitudes, behaviors, and overall organizational outcomes (Coyle-Shapiro et al., 2019; Mohammad et al., 2023). The psychological contract pertains to an individual's perceptions of the mutual responsibilities and expectations between themselves and their organization, which are not formally stated in a written contract (Rousseau, 1989). A PCB happens when an employee believes that their organization has not fulfilled one or more commitments in the unspoken agreement between them (Gong, Sims (2023); Morrison & Robinson, 1997). Employees continuously evaluate their employment relationship, comparing their expectations with the actual experiences in the workplace (Tekleab et al., 2020). This ongoing assessment can lead to perceptions of breach when discrepancies are identified, even if the organization perceives it has met its duties. The consequences of psychological contract breach are far-reaching and predominantly negative. At the individual level, PCB has been related to diminished job satisfaction, decreased organizational commitment, augmented turnover intentions, and decreased job performance (Mohammad et al., 2023; Zhao et al., 2007). Moreover, PCB can lead to emotional exhaustion, reduced well-being, and increased cynicism towards the organization (Mohammad et al., 2023; Reimann & Guzy, 2017). PCB has also explored the ripple effects of psychological contract breach beyond the individual level. PCB can negatively impact team performance and organizational citizenship behaviors. Furthermore, the contagion effect of psychological contract breach has been observed, where an individual's perception of the breach can influence their colleagues' attitudes and behaviors (Tomprou et al., 2015).

AI-induced job insecurity and PCB. Our second hypothesis explores how AI-induced job insecurity influences psychological contract perceptions, addressing our aim to understand the psychological mechanisms at play in this relationship. The AI-induced job insecurity-PCB association is explained through Social Information Processing Theory, providing a comprehensive understanding of this complex phenomenon in the modern workplace.

The Social Information Processing Theory (SIPT) provides another theoretical lens to understand the association between

AI-induced job insecurity and PCB. SIPT posits that individuals' attitudes and behaviors are shaped by the social context and the information available in their environment (Salancik & Pfeffer, 1978). In the context of AI implementation, employees may gather and process information from various sources, including organizational communication, peer discussions, and media reports, to form their perceptions of job insecurity and evaluate their psychological contracts. Prior research by Bankins et al. (2020) applies SIPT to the context of technological change, arguing that employees' interpretations of organizational actions and policies related to new technologies are significantly influenced by social cues and collective sensemaking processes. If the prevailing narrative within the organization or broader social context frames AI as a threat to job security, employees may be more likely to perceive a misalignment between their expectations and organizational practices, leading to PCB.

Hypothesis 2: AI-induced job insecurity is positively associated with PCB.

PCB and PEBW. The third hypothesis examines the relationship between PCB and PEBW, furthering our objective to understand the factors influencing pro-environmental behaviors in the context of technological change. The relationship between PCB and PEBW can be elucidated through the Social Exchange Theory, providing a comprehensive understanding of this complex interaction in the organizational context.

The Social Exchange Theory (SET) offers a foundational perspective for understanding this relationship (Cropanzano & Mitchell, 2005). In the workplace, employees engage in a series of exchanges with their organization, expecting a balance of give-and-take over time. When employees perceive a PCB, they may interpret this as an imbalance in the exchange relationship, leading to a reduction in their willingness to reciprocate with positive discretionary behaviors, including PEBW. Prior research by Tian et al. (2020) extends SET within the realm of environmental behaviors, suggesting that employees' perceptions of organizational support for environmental initiatives significantly influence their engagement in PEBW. When a PCB occurs, employees may perceive a lack of organizational support, not only in general terms but also specifically for environmental efforts. This perceived lack of support may diminish their motivation to engage in PEBW, as they no longer see these actions as part of a mutually beneficial exchange.

Hypothesis 3: PCB is negatively associated with PEBW.

The mediating role of PCB in the AI-induced job insecurity-PEBW link. The current paper suggests that PCB would mediate the AI-induced job insecurity-PEBW link. Our fourth hypothesis integrates the previous three, proposing a mediating mechanism that explains the relationship between AI-induced job insecurity and PEBW. The Context-Attitudes-Behavior (CAB) framework provides a compelling lens through which to delve into the complex link between AI-induced job insecurity, PCB, and PEBW. This framework suggests a sequential process where contingent elements affect attitudes, which in turn build behaviors (Guagnano et al., 1995). Applying this framework to our research model offers valuable insights into the mediating role of PCB.

In our model, AI-induced job insecurity represents the contextual factor. The implementation of AI technologies in the workplace creates a unique environmental condition that can significantly impact employees' perceptions and experiences. Recent research by Brougham and Haar (2020) indicates that the introduction of AI can create a climate of uncertainty and

perceived threat to job security, forming a distinct context within which employees operate.

PCB, in this framework, serves as the attitudinal component. The perception of a breach in the psychological contract reflects an employee's evaluation of the employment relationship in light of the contextual changes brought about by AI implementation. Drawing on the work of Coyle-Shapiro et al. (2019), we can conceptualize PCB as a cognitive and affective response to perceived discrepancies between expected and received organizational support, particularly in the face of technological changes.

PEBW represents the behavioral outcome in our model. These voluntary activities intended to enhance the organization's ecological performance are influenced by both the context and the attitudes formed within that context. Previous studies by Tian et al. (2020) demonstrate that employee engagement in PEBW is sensitive to both organizational context and individual attitudes toward the organization.

The CAB framework proposes that the impact of context on behavior is often mediated by attitudes. In our model, this implies that AI-induced job insecurity may not directly lead to changes in PEBW, but rather operates through its effect on PCB. This mediation hypothesis aligns with the sequential nature of the CAB framework, suggesting that the influence of AI-induced job insecurity on PEBW operates through its impact on PCB. By increasing PCB, AI-induced job insecurity creates an attitudinal ground that is less conducive to PEBW.

Hypothesis 4: PCB mediates the negative relationship between AI-induced job insecurity and PEBW.

The moderating role of ethical leadership in the AI-induced job insecurity-PCB link. We posit that ethical leadership plays a role of a moderator, diminishing the negative impact of AI-induced job insecurity on PCB. Given our prior discussions, it seems evident that AI-induced job insecurity might increase PCB. Nevertheless, it is essential to acknowledge that the influence of AI-induced job insecurity on PCB differs among various organizational environments.

Ethical leadership as a moderator. Ethical leadership focuses on the moral dimensions of leadership and its impact on followers, organizations, and society at large. This construct has gained significant attention due to its crucial role in fostering positive organizational cultures, enhancing employee well-being, and promoting sustainable business practices Brown & Treviño, (2006). At its core, ethical leadership refers to “the demonstration of normatively appropriate conduct through personal actions and interpersonal relationships, and the promotion of such conduct to followers through two-way communication, reinforcement, and decision-making” (Brown et al., 2005, p. 120). The definition emphasizes the dual aspects of ethical leadership: being a moral person and a moral manager. The outcomes of ethical leadership are strongly positive. At the individual level, ethical leadership has been related to increased job satisfaction, organizational commitment, organizational trust, and work engagement (Le et al., 2023; Ng & Feldman, 2015). It also promotes ethical behavior and knowledge-sharing behavior among followers, reduces workplace deviance, and enhances employee well-being (Bedi et al., 2016; Le et al., 2023; Lin et al., 2016; Rasheed et al., 2024). At the organizational level, ethical leadership contributes to improved firm performance, enhanced corporate social responsibility, and stronger stakeholder relationships (Eisenbeiss & Brodbeck, 2014; Eisenbeiss et al., 2015; Kalra et al., 2023).

The moderating influence of ethical leadership in the AI-induced job insecurity-PCB link. Our final hypothesis examines

the role of ethical leadership in this process, addressing our objective to identify factors that might mitigate the negative effects of AI-induced job insecurity. The moderating effect of ethical leadership in the AI-induced job insecurity-PCB link can be understood through several theoretical lenses, providing a comprehensive framework for our fifth hypothesis.

First, the Social Information Processing Theory (SIPT) offers a valuable perspective on this moderation effect. SIPT posits that individuals' attitudes and behaviors are shaped by the social cues and information available in their environment (Salancik & Pfeffer, 1978). Ethical leaders, characterized by their fairness, integrity, and concern for others, provide important social cues that can influence employees' interpretations of organizational events (Brown & Treviño, 2006).

When the extent of ethical leadership is high, members would receive clear, honest communication about AI implementation and its potential impacts. This transparency can help mitigate feelings of uncertainty and threat associated with AI-induced job insecurity. For example, in a high-tech company implementing AI in its customer service operations, an ethical leader might proactively communicate the organization's commitment to reskilling employees and finding alternative roles for those affected by AI. This approach can help maintain employees' trust and reduce the likelihood of perceived psychological contract breaches.

Conversely, when ethical leadership is low, the lack of clear, ethical guidance may exacerbate the harmful influences of AI-induced job insecurity. Within the scenario, members may feel left in the dark about the organization's AI strategy and its implications for their jobs. For instance, in a manufacturing firm introducing AI-driven automation, low ethical leadership might manifest as a lack of transparency about the timeline and scope of automation, leading to increased anxiety and a higher likelihood of perceived psychological contract breaches.

Second, the Social Exchange Theory (SET) also supports this moderation hypothesis. SET posits that employment relationships are based on reciprocal exchanges (Cropanzano & Mitchell, 2005). Ethical leaders, by demonstrating care and concern for followers, can create a sense of obligation and positive reciprocity.

When ethical leadership is high, employees may feel a stronger sense of organizational support, even in the face of AI-induced job insecurity. This perceived support can buffer against perceptions of PCB. For example, in a healthcare organization implementing AI for diagnostic assistance, an ethical leader might emphasize the organization's engagement in employee well-being and professional development alongside AI implementation. This approach can strengthen the social exchange relationship, potentially mitigating the negative effects of job insecurity.

Conversely, low ethical leadership may fail to foster this sense of positive reciprocity. In this case, AI-induced job insecurity may more readily translate into perceptions of PCB. For instance, in an advertising agency introducing AI for campaign optimization, low ethical leadership might manifest as a focus on AI's benefits for the company without addressing employee concerns. This approach may weaken the social exchange relationship, amplifying the association between AI-induced job insecurity and PCB.

Hypothesis 5: Ethical leadership moderates the positive relationship between AI-induced job insecurity and PCB, such that the relationship is weaker when ethical leadership is high.

Method

Participants and procedure. This investigation encompassed a heterogeneous assembly of employees, who were 20 years of age or older, hailing from a broad array of firms across South Korea. The methodology for gathering data was segmented into three

distinct phases, employing a tripartite wave time-lagged design to meticulously examine temporal evolutions. Recruitment of participants was executed through a premier digital research platform, renowned for its substantial repository of around 5.52 million prospective respondents (Kim et al., 2024). In the initial registration process conducted online, individuals affirmed their ongoing employment and undertook a confirmation step, necessitating either a cellular phone number or an electronic mail address, thus fortifying the security measures of the data acquisition procedure. The utility of digital questionnaires in amassing a comprehensive and diverse sample is corroborated by its established validity and reliability in preceding studies (Landers & Behrend, 2015).

The aim of this scholarly work was to collect time-staggered data from actively employed workers within various corporations in South Korea, thereby addressing the inherent shortcomings often seen in cross-sectional analyses. The sophisticated digital instruments employed in this inquiry facilitated meticulous monitoring of participant involvement throughout the duration of the survey, guaranteeing uniform participation during all phases of data collection. The scheduling of data collection was strategically set to transpire at intervals of every five to six weeks, with each survey window available for a duration of two to three days to optimize participant responses. Rigorous measures were implemented to uphold the integrity of data, including the employment of geo-IP restriction mechanisms to avert any excessively prompt replies, thus ensuring the authenticity and trustworthiness of the study findings. The chosen temporal gaps between the waves of data collection (5–6 weeks) were predicated on several factors (Kim et al., 2024). Primarily, this duration sufficiently reduces the risk of common method bias (Podsakoff et al., 2012), yet remains brief enough to observe the evolving dynamics of the studied constructs. Furthermore, analogous temporal intervals have been previously utilized in longitudinal research on job insecurity and behavioral dynamics in the workplace, demonstrating their adequacy in capturing shifts in these phenomena (e.g., Vander Elst et al., 2014). Additionally, this timeframe permitted the completion of the data gathering within a singular fiscal quarter, thus minimizing the influence of significant corporate transformations that typically occur between quarters.

Survey coordinators actively initiated contact with potential subjects to solicit their engagement in the research. The team explicitly assured prospective participants of the voluntary nature of their contribution and the strict confidentiality and exclusive research utilization of their data. Following the acquisition of informed consent from willing individuals, rigorous ethical guidelines were strictly adhered to throughout the study (Kim et al., 2024). For their involvement, participants received financial compensation between eight and nine dollars.

To achieve a representative sample, a stratified random sampling approach was utilized, considering essential demographic and occupational characteristics. This technique entailed the random selection of subjects from predefined strata to mitigate biases linked to variables such as gender, age, job title, educational attainment, and sector of employment. Stratification criteria included gender, age groups (20–29, 30–39, 40–49, 50–59), professional levels (staff, assistant manager, manager/deputy general manager, department/general manager or above), educational qualifications (high school or less, community college, bachelor's degree, master's degree or higher), and industry sectors. Within each stratum, individuals were chosen via a computer-generated sequence of random numbers. The research team meticulously monitored participant activity across digital interfaces to ensure consistent involvement throughout the three phases of the survey.

Regarding participant turnout, the initial phase of the survey saw 811 employees respond. This number reduced to 573 by the second checkpoint, and the concluding phase logged responses from 394 employees. Following data collection, an extensive cleaning procedure was implemented to exclude any incomplete records. The research ultimately based its findings on 391 respondents who successfully completed all stages of the survey, resulting in a final participation rate of 48.21%. Calculations for the sample size were informed by academic recommendations, including the application of G*Power for statistical power analysis.

Measures. In the initial survey phase, we queried participants on their experiences of AI-induced job insecurity and the level of ethical leadership. The subsequent questionnaire was dedicated to evaluating participants' perceptions of PCB. By the time of the third questionnaire, the study had gathered information regarding the degrees of PEBW among the respondents. Each variable was quantitatively assessed through multiple-item metrics, employing a 5-point Likert scale for evaluations.

AI-induced job insecurity (point in time 1, as reported by workers). The AI-induced job insecurity scale was adapted from Kraimer et al., (2005) job insecurity scale. This paper modified the original items to specifically address the context of AI implementation at work. For example, the original item "I am confident that I will be able to work for my organization as long as I wish" was adapted to "I am confident that I will be able to continue working for my organization despite the introduction of AI technologies". This adaptation process involved cognitive interviews with a panel of experts in organizational psychology and AI to ensure content validity. The adapted scale consists of five items: "The introduction of artificial intelligence technologies has made my job at work insecure", "If my current organization faces economic problems, my job will be replaced by artificial intelligence", "Even if I want to, I will not be able to keep my present job due to the adoption of artificial intelligence", "If the organization's economic situation worsens, the organization will introduce artificial intelligence technology, and my current job may disappear", and "Even if I want to, I am not confident that I can continue to work at my organization due to the introduction of artificial intelligence technology". These items were designed to reflect the perceived threat of job loss or job instability specifically due to AI implementation, aligning with the original scale's focus on job insecurity but within the context of technological change. A value of 0.951 was reported for Cronbach's alpha.

Ethical leadership (point in time 1, as reported by workers). The 10 items from ethical leadership scale developed by Brown and his colleagues (2005) were used to assess ethical leadership. Item samples comprised: "My leader disciplines employees who violate ethical standards", "My leader discusses business ethics or values with employees", "My leader sets an example of how to do things the right way in terms of ethics", "When making decisions, my leader asks what is the right thing to do", "My leader listens to what employees have to say", and "My supervisor can be trusted". The scale exhibited a Cronbach's alpha of 0.854.

PCB (point in time 2, as reported by workers). We utilized modified five items from the psychological contract breach scale relying on previous research (Coyle-Shapiro & Kessler, 2000). Sample items include: "Almost all the promises made by my employer during recruitment have not been kept thus far", "I have not received everything promised to me in exchange for my contributions", "My employer has broken many of its promises to

Table 1 Descriptive characteristics of the sample.	
Characteristic	Percent
Gender	
Men	50.4%
Women	49.6%
Age (years)	
20–29	21.5%
30–39	23.8%
40–49	26.9%
50–59	27.9%
Education	
High school or below	12.5%
Community college	19.2%
Bachelor's degree	54.7%
Master's degree or higher	13.6%
Position	
Staff	43.2%
Assistant manager	16.4%
Manager or deputy general manager	23.7%
Department/general manager or director and above	16.6%
Firm Size	
1–9 employees	15.1%
10–29 employees	18.2%
30–49 employees	10.5%
50–99 employees	15.9%
100–149 employees	8.4%
150–299 employees	7.2%
300–449 employees	3.8%
500–999 employees	6.9%
1000–4999 employees	8.7%
Above 5000 employees	5.4%
Industry Type	
Manufacturing	21.5%
Services	14.8%
Construction	11.3%
Health and welfare	16.1%
Information services and telecommunications	9.2%
Education	17.1%
Financial/insurance	2.0%
Consulting and advertising	0.8%
Others	7.2%

me even though I've upheld my side of the deal", "I feel betrayed by my organization", and "I feel that my organization has violated the contract between us". The scale exhibited a Cronbach's α value of 0.907.

PEBW (point in time 3, as reported by workers). The present study followed the previous research by using eight items from the PEBW scale (Boiral & Paillé, 2012; Paillé & Boiral, 2013). The items consist of: "In my work, I weigh the consequences of my actions before doing something that could affect the environment", "I voluntarily carry out environmental actions and initiatives in my daily work activities", "I stay informed of my company's environmental initiatives", "I make suggestions to my colleagues about ways to protect the environment more effectively, even when it is not my direct responsibility", "I actively participate in environmental events organized in and/or by my company", "I undertake environmental actions that contribute positively to the image of my organization", "I volunteer for projects, endeavors or events that address environmental issues in my organization", "I spontaneously give my time to help my colleagues take the environment into account in everything they do at work", "I encourage my colleagues to adopt more environmentally conscious behavior". A value of 0.936 was reported for Cronbach's α .

Control variables. Based on previous research (Boiral & Paillé, 2012; Paillé & Boiral, 2013), we controlled for factors, such as gender, position, education, and tenure by including these variables in our analysis. The first survey was when these control variables were gathered. According to the research, it is helpful to include control variables like as gender, education level, position, and tenure when studying PEBW. Careful consideration of these control factors allows a more accurate assessment of the main variables of interest and reduces the impact of omitted variable bias.

Statistical analysis. To examine the connections between the research variables, we utilized SPSS version 28 to conduct a Pearson correlation analysis following data collection. Anderson, Gerbing (1988) proposed a two-stage methodology, which we precisely followed: a measurement model and a structural model. We employed the AMOS 26 program and utilized the maximum likelihood (ML) estimate technique to examine the structural model using moderated mediation analysis. After confirming the measurement model with Confirmatory Factor Analysis (CFA), we adhered to established procedures in Structural Equation Modeling (SEM).

We utilized several model fit indices to evaluate the appropriateness of our structural equation model. The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) compare the fit of our model to a more restricted, nested baseline model. Values above 0.90 indicate good fit (Hu & Bentler, 1999). The Root Mean Square Error of Approximation (RMSEA) estimates the lack of fit in our model compared to a perfect (saturated) model, with values below 0.06 suggesting a good fit (Hu & Bentler, 1999). Previously published academic criteria deemed the model fits satisfactory if the values of CFI and TLI were better than 0.90 (Please Refer to Table 1).

Results

Descriptive statistics. Our research revealed significant correlations among the key variables of interest: AI-induced job insecurity, ethical leadership, PCB, and PEBW. As shown in Table 2, AI-induced job insecurity was positively correlated with PCB ($r = 0.24, p < 0.01$) and negatively correlated with PEBW ($r = -0.11, p < 0.05$), providing initial support for our hypotheses. Notably, ethical leadership showed a significant positive correlation with PEBW ($r = 0.25, p < 0.01$) and a negative correlation with PCB ($r = -0.16, p < 0.01$), highlighting its potential protective role. These correlations are detailed in Table 2, which you can find inserted below.

Measurement model. To examine the sufficiency of our measuring model, the current research conducted a confirmatory factor analysis (CFA) on all questions to assess the discriminant validity of our four primary variables: AI-induced job insecurity, ethical leadership, PCB, and PEBW. A series of chi-square difference tests were conducted to compare the 4-factor model (AI-induced job insecurity, ethical leadership, PCB, and PEBW) with alternative models. The 3-factor model had a chi-square value of 1029.713 with 148 degrees of freedom, a CFI of 0.837, a TLI of 0.812, and an RMSEA of 0.124. The 2-factor model had a chi-square value of 2199.639 with 150 degrees of freedom, a CFI of 0.621, a TLI of 0.568, and an RMSEA of 0.187. The one-factor model had a chi-square value of 3056.525 with 151 degrees of freedom, a CFI of 0.463, a TLI of 0.392, and an RMSEA of 0.222. The fit indices of each factor model suggested that the 4-factor model outperformed the other models in terms of fit. The chi-square value was 309.497 with 145 degrees of freedom. Additionally, the CFI was 0.970, the TLI was 0.964, and the RMSEA

Table 2 Correlation among research variables.										
	Mean	S.D.	1	2	3	4	5	6	7	
1. Gender_T1	1.50	0.50	-							
2. Education_T1	2.69	0.86	−0.03	-						
3. Tenure_T1	65.32	72.53	−0.04	0.04	-					
4. Position_T1	2.37	1.50	−0.30**	0.30**	0.30**	-				
5. AIJI_T1	2.42	1.00	−0.12*	0.08	−0.05	0.02	-			
6. EL_T1	3.15	0.62	−0.05	0.10*	0.01	0.12*	0.16**	-		
7. PCB_T3	2.59	0.82	−0.19**	0.01	−0.03	0.14**	0.24**	−0.16**	-	
8. PEBW_T4	3.18	0.80	0.11*	0.10	0.10	0.06	−0.11*	0.25**	−0.22**	

Notes: * $p < 0.05$. ** $p < 0.01$. S.D. means standard deviation, AIJI means AI-induced Job Insecurity, EL means ethical leadership, PCB means psychological contract breach, PEBW means pro-environmental behavior at work. As for gender, males are coded as 1 and females as 2. As for positions, general manager or higher are coded as 5, deputy general manager and department manager 4, assistant manager 3, clerk 2, and others below clerk as 1. As for education, the “below high school diploma” level is coded as 1, the “community college” level as 2, the “bachelor’s” level as 3, and the “master’s degree or more” level is coded as 5.

was 0.054. Further chi-square tests verified that the four research variables possessed enough discriminant validity.

Structural model. Our moderated mediation model integrates the mediation and moderation analyses. The approach allows us to examine not only how AI-induced job insecurity affects PEBW through PCB (mediation), but also how ethical leadership influences the strength of the relationship between AI-induced job insecurity and PCB (moderation). This comprehensive model provides a nuanced understanding of the complex relationships among our variables of interest (Hayes, 2018). Within this framework, this paper investigated how the impact of AI-induced job insecurity on PEBW was mediated by PCB. Furthermore, ethical leadership was regarded as a moderator that can weaken the augmenting impact of AI-induced job insecurity on PCB.

To implement our moderation analysis, we formed an interaction term by combining the mean-centered factors of AI-induced job insecurity and ethical leadership. The process of mean-centering is crucial as it aids in diminishing the problems of multicollinearity that often emerge when constructing interaction terms (Aiken & West, 1991). This approach not only mitigated multicollinearity but also preserved the strength of correlations, thereby improving the dependability of our moderation analysis (Brace et al., 2003).

To assess the extent of potential multicollinearity, we calculated variance inflation factors (VIF) and corresponding tolerance levels, adhering to the procedure described by Brace et al. (2003). The analysis revealed that the variables of AI-induced job insecurity and ethical leadership registered VIF values of 1.025, with tolerance levels correspondingly set at 0.975. These figures suggest that our variables did not suffer from pronounced multicollinearity issues, as evidenced by VIF values substantially below the widely recognized limit of 10, and tolerance values significantly exceeding the minimum standard of 0.2 (Brace et al., 2003).

Findings from the mediation evaluation. To find the most appropriate mediation model, we employed a chi-square difference test to evaluate whether a full mediation model was more suitable than a partial mediation one. The direct association between AI-induced job insecurity and PEBW was not considered in the full mediation model, in contrast to the partial mediation one. Both models had a strong fit, with the full mediation model displaying fit indices of ($\chi^2 = 346.308$ (df = 158), CFI = 0.961, TLI = 0.953, RMSEA = 0.055), and the partial mediation one showing ($\chi^2 = 345.541$ (df = 157), CFI = 0.961, TLI = 0.952, RMSEA = 0.055). We employed the chi-square difference test to compare the full mediation model with the partial mediation model. This test is crucial for determining whether the addition of

a direct path from AI-induced job insecurity to PEBW (in the partial mediation model) significantly improves model fit compared to the more parsimonious full mediation model (Byrne, 2010). A non-significant chi-square difference suggests that the additional path does not significantly improve model fit, supporting the more parsimonious model (Kline, 2015). This approach allows us to empirically justify our choice of mediation model, ensuring that we do not unnecessarily complicate our model with non-significant paths. The outcomes of the chi-square difference test indicated that the full mediation model had a superior fit, as indicated by the non-significant chi-square difference ($\Delta \chi^2 [1] = 0.767$, $p > 0.05$) between the models. This outcome proposes that AI-induced job insecurity affects PEBW indirectly, through PCB. Additionally, we utilized control variables, including tenure, gender, educational level, and occupational position. These variables, however, did not achieve statistical significance in influencing PEBW.

Contrary to our initial expectations, Hypothesis 1, which proposed a direct negative relationship between AI-induced job insecurity and PEBW, was not supported ($\beta = -0.048$, $p > 0.05$). This result underscores the importance of our mediation hypothesis (H4) and highlights the need to consider intervening psychological processes, such as mediating or moderating factors when examining the effects of AI-induced job insecurity on employee behaviors.

The results affirm Hypothesis 2, indicating a positive impact of AI-induced job insecurity on PCB ($\beta = 0.304$, $p < 0.001$), and Hypothesis 3, which indicates that PCB substantially decreases PEBW ($\beta = -0.240$, $p < 0.001$). The results are depicted in Table 3.

Bootstrapping. In order to examine Hypothesis 4, which suggests that the AI-induced job insecurity-PEBW link is mediated by PCB, this study utilized a bootstrapping technique with a sample size of 10,000 (Shrout & Bolger, 2002). In order for the statistical significance of the indirect effect of AI-induced job insecurity on PEBW to be established, the 95% bias-corrected confidence interval (CI) should not include zero. The bootstrapping results revealed a significant indirect effect of AI-induced job insecurity on PEBW through PCB (95% CI: -0.125 to -0.036). This finding supports Hypothesis 4 and suggests that while AI-induced job insecurity may not directly affect PEBW, it does so indirectly by increasing employees’ perceptions of psychological contract breach (Please See Fig. 1).

The significant mediating role of PCB in the relationship between AI-induced job insecurity and PEBW aligns with the Context-Attitudes-Behaviour framework (Guagnano et al., 1995). Our findings suggest that AI-induced job insecurity (context) influences PCB (attitude), which in turn affects PEBW (behavior). This mediation (indirect) effect ($\beta = -0.073$, $p < 0.01$)

Table 3 Results of structural model.

Hypothesis	Path (Relationship)	Unstandardized Estimate	S.E.	Standardized Estimate	Supported
1	AI-induced Job Insecurity -> PEBW	-0.036	0.041	-0.048	No
2	AI-induced Job Insecurity -> PCB	0.221	0.038	0.304***	Yes
4	PCB -> PEBW	-0.248	0.056	-0.240***	Yes
5	AI-induced Job Insecurity × Ethical Leadership	-0.161	0.054	-0.149**	Yes

Notes: ** $p < 0.01$. *** $p < 0.05$. Estimate indicates standardized coefficients. S.E. means standard error. PCB means psychological contract breach, PEBW means pro-environmental behavior at work. The path from AI-induced Job Insecurity to PEBW was in the partial mediation model, which was not finally accepted.

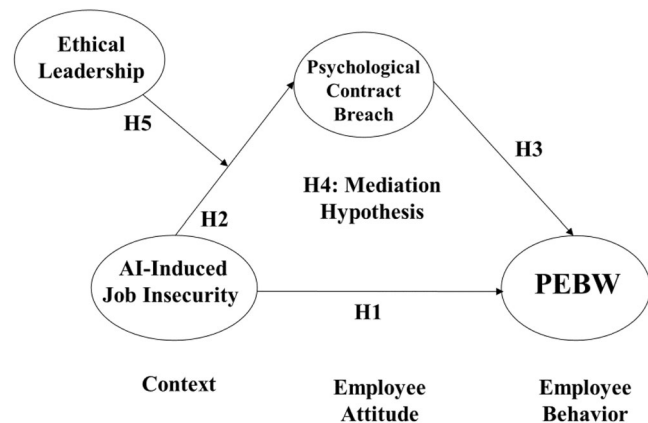


Fig. 1 Theoretical model (PEBW means pro-environmental behavior at work).

underscores the importance of considering employees’ psychological experiences in understanding the impact of technological changes on pro-environmental behaviors. Furthermore, while our results support the mediating role of PCB, alternative explanations should be considered. For example, the relationship between AI-induced job insecurity and PEBW might be influenced by factors not included in our model, such as organizational culture or individual differences in technology acceptance. These insights are detailed in Table 4.

Findings from the moderation evaluation. The purpose of our moderation analysis was to investigate the potential moderating influence of ethical leadership on the relationship between AI-induced job insecurity and PCB. To fulfill this aim, our study established an interaction term by normalizing the mean values of AI-induced job insecurity and ethical leadership, which was instrumental in addressing potential multicollinearity and preserving the transparency of our evaluation. The interaction term proved to be statistically significant ($\beta = -0.149$, $p < 0.01$), indicating that our moderation analysis (Fig. 2) revealed a notable interaction effect between AI-induced job insecurity and ethical leadership on PCB. This finding corroborates Hypothesis 5 and demonstrates that ethical leadership can mitigate the adverse impacts of AI-induced job insecurity on perceptions of psychological contracts.

Discussion

This study was designed to explore the intricate dynamics among AI-induced job insecurity, perceived contract breach (PCB), pro-environmental behavior at work (PEBW), and the moderating influence of ethical leadership. The findings shed light on the ways in which technological advancements, especially the

Table 4 Direct, indirect, and total effects of the final research model.

Model (Hypothesis 4)	Direct Effect	Indirect Effect	Total Effect
AI-induced Job Insecurity -> PCB -> PEBW	0.000	-0.073	-0.073

Notes: All values are standardized. PCB means psychological contract breach, PEBW means pro-environmental behavior at work.

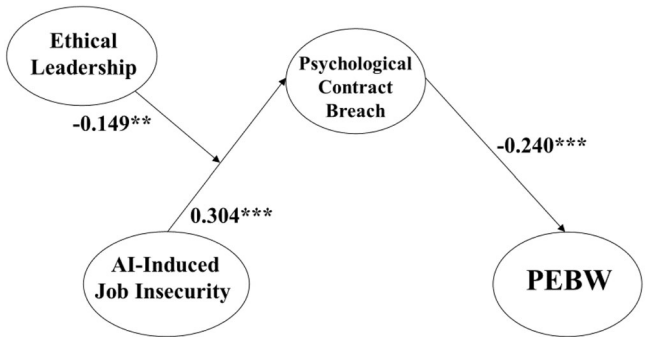


Fig. 2 Coefficient values of our research Model (** $p < 0.01$, *** $p < 0.001$. All values are standardized, PEBW means pro-environmental behavior at work).

implementation of AI, affect employee behaviors and organizational sustainability initiatives (Please See Fig. 3).

Contrary to our initial hypothesis, we did not observe a direct negative association between AI-induced job insecurity and PEBW (H1). This unexpected outcome implies that the impact of AI-induced job insecurity on pro-environmental behaviors is more complex than previously considered. This aligns with recent studies suggesting that the connection between job insecurity and discretionary behaviors is not consistently direct (Sverke et al., 2019). The lack of a direct link emphasizes the need to consider intermediary variables to fully grasp the intricate interplay between technological changes and employee behaviors.

Our findings revealed that AI-induced job insecurity does not directly affect PEBW, contrary to our initial hypothesis. This unexpected finding suggests that the relationship between AI-induced job insecurity and PEBW is more complex than initially theorized. It aligns with recent literature suggesting that the impact of job insecurity on discretionary behaviors may be indirect, operating through mediating mechanisms (Shoss et al., 2023). This result underscores the importance of our mediation hypothesis (H4) and highlights the need to consider intervening psychological processes when examining the effects of AI-induced job insecurity on employee behaviors. Several alternative mechanisms might explain this finding. First, it’s possible that AI-

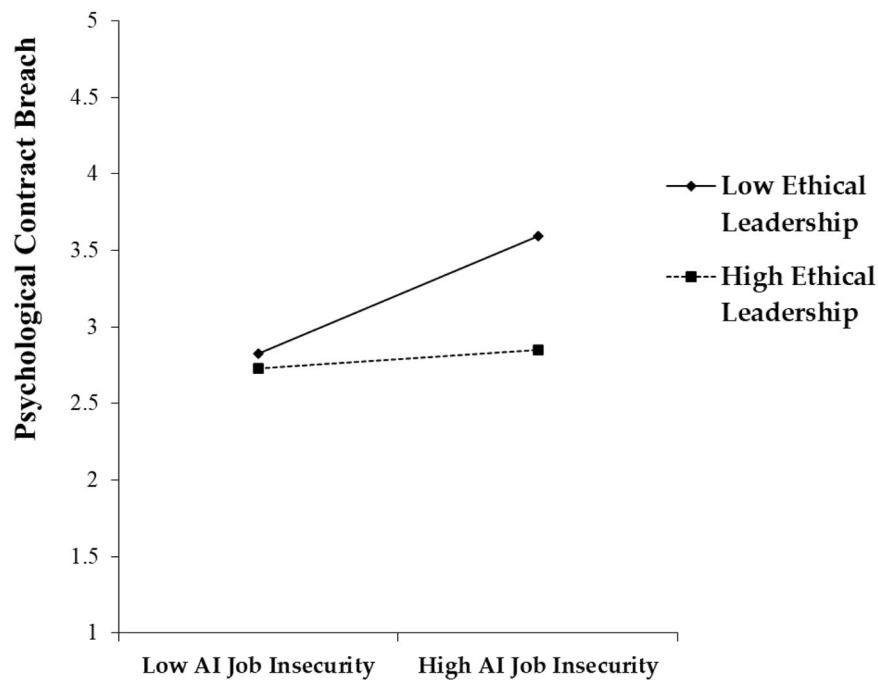


Fig. 3 Moderating effect of ethical leadership in the AI-induced job insecurity-psychological contract breach link.

induced job insecurity triggers a complex set of reactions that have counterbalancing effects on PEBW. For instance, while job insecurity might reduce some employees' willingness to engage in discretionary behaviors, it might simultaneously motivate others to engage in PEBW as a form of impression management or job preservation strategy (Bolino, 1999). Second, the relationship between AI-induced job insecurity and PEBW might be moderated by factors not captured in our model, such as environmental values (Kim et al., 2017) or perceived organizational support (Paillé & Raineri, 2015). Future research could explore these potential moderating factors. Lastly, the timeframe of our study might not have been sufficient to capture the full effects of AI-induced job insecurity on PEBW, suggesting the need for longer-term longitudinal studies in this area (Sverke et al., 2019).

Our results robustly affirm the positive association between AI-induced job insecurity and PCB (H2). This aligns with psychological contract theory, which argues that significant organizational changes can lead to perceptions of breached implicit agreements between employees and employers (Rousseau & McLean Parks, 1993). The deployment of AI technologies, perceived as jeopardizing job security, seems to prompt a reassessment of the employment relationship, potentially diminishing the perceived mutual obligations between employees and the organization. This insight expands our comprehension of how technological shifts can alter psychological contracts in the workplace.

The study further verifies the negative relationship between PCB and PEBW (H3), which is in line with social exchange theory (Cropanzano & Mitchell, 2005). When employees sense a breach in their psychological contract, they may respond by reducing their involvement in discretionary behaviors that benefit the organization, including pro-environmental activities. This finding highlights the significance of maintaining robust psychological contracts to promote organizational citizenship behaviors, especially those connected to environmental sustainability.

Significantly, our analysis substantiates the mediating role of PCB in the linkage between AI-induced job insecurity and PEBW (H4). This offers a deeper understanding of the mechanisms through which technological shifts affect employee behaviors. It suggests that AI-induced job insecurity does not directly diminish

pro-environmental behaviors; instead, it influences these behaviors through its impact on employees' perceptions of their psychological contracts. This mediation aligns with the Context-Attitudes-Behavior (CAB) framework (Guagnano et al., 1995), illustrating how contextual factors (AI deployment) affect attitudes (perceptions of psychological contract breach), which in turn dictate behaviors (PEBW).

The moderating role of ethical leadership in the relationship between AI-induced job insecurity and PCB (H5) provides valuable insights into possible mitigation strategies for organizations implementing AI. This finding correlates with and extends previous research on ethical leadership (Brown & Treviño, 2006) to the realms of technological change and sustainability. Ethical leaders, by exhibiting fairness, integrity, and a commitment to employee well-being, seem to mitigate the adverse effects of AI-induced job insecurity on psychological contract perceptions. This underscores the pivotal role of leadership in navigating the human aspects of technological changes and sustaining employee involvement in sustainability initiatives.

Our findings offer several concrete recommendations for organizational leaders dealing with AI-induced job insecurity. First, leaders should establish regular channels for communicating about AI initiatives, their potential impacts on job roles, and the organization's plans for workforce adaptation. This transparent communication strategy could include AI-focused town hall meetings and dedicated update newsletters (Brynjolfsson & McAfee, 2017). Additionally, organizations should invest in reskilling and upskilling programs that prepare employees for evolving job roles in an AI-enhanced workplace. For instance, companies like IBM have implemented 'AI Ethics Boards' that involve employees in AI-related decision-making processes (Fountain et al., 2019). Organizations should also prioritize the development of ethical leadership capabilities, particularly among managers overseeing AI implementation, which could involve incorporating ethical decision-making modules into leadership training programs (Brown & Treviño, 2006). Furthermore, forming cross-functional teams that include both technical experts and employee representatives can help ensure that AI implementation considers both technological and human factors,

potentially reducing job insecurity (Shrestha et al., 2019). Finally, organizations should create and communicate clear career development paths that account for the integration of AI, helping employees visualize their future in the company despite technological changes (Makarius et al., 2020).

Theoretical Implications. This research offers several significant theoretical implications that contribute to and extend previous works in organizational behavior, environmental psychology, and technology management.

Firstly, this study advances the theoretical understanding of employee PEBW by integrating it with the emerging concept of AI-induced job insecurity. By doing so, it expands the scope of PEBW antecedents beyond traditional organizational and individual factors (Norton et al., 2015) to include technological disruption as a critical contextual influence. This integration bridges the gap between technological advancement literature and environmental sustainability research, offering a novel perspective on how emerging technologies shape employee behaviors. The findings contribute to the refinement of the Context-Attitudes-Behavior (CAB) framework (Guagnano et al., 1995) by demonstrating how AI, as a contextual factor, influences pro-environmental attitudes and behaviors. This expansion of the CAB framework to include technological contexts enhances its applicability in contemporary organizational settings and provides a more comprehensive model for understanding PEBW in the digital age.

Secondly, the exploration of psychological contract breach as a mediating mechanism offers valuable perspectives on the psychological mechanisms underlying the link between AI-induced job insecurity and PEBW. This contribution extends psychological contract theory (Rousseau, 1989) by examining how technological changes can alter employees' perceptions of their implicit agreements with organizations. By demonstrating the role of PCB in the relationship, the study enriches our understanding of the cognitive and affective pathways through which job insecurity influences discretionary behaviors. This finding not only advances psychological contract theory but also contributes to the broader literature on employee responses to organizational change (Oreg et al., 2011), highlighting the importance of perceived organizational obligations in shaping employee behaviors during periods of technological disruption.

Thirdly, the investigation of ethical leadership as a moderating factor provides significant theoretical implications for leadership research within the realm of technological change and sustainability. Through investigating how ethical leadership influences the relationship between AI-induced job insecurity and PEBW, this study extends ethical leadership theory (Brown & Treviño, 2006) into the domain of environmental sustainability and technological disruption. The findings contribute to our understanding of how leadership practices can weaken the negative influences of AI-induced job insecurity on pro-environmental behaviors, offering novel perspectives on the role of leadership in fostering organizational sustainability in turbulent technological environments. The amalgamation of ethical leadership with AI and sustainability research offers a more intricate theoretical structure for comprehending the effectiveness of leadership in the face of complex, contemporary organizational challenges.

Lastly, the study's comprehensive theoretical approach, which integrates multiple frameworks including Social Information Processing Theory, the Uncertainty Management Model, and Social Exchange Theory, offers a robust foundation to understand the intricate interaction among technological change, members' perceptions, leadership, and pro-environmental behaviors. This integrative approach advances theoretical development in

organizational behavior by demonstrating how diverse theoretical perspectives can be synthesized to explain complex phenomena. The current research's theoretical model offers a comprehensive framework for future works, encouraging a more holistic approach to investigating the sustainability of organizations within the realm of technological change. Through illustrating how these theories can be combined to explain the complex associations between AI, job insecurity, psychological contracts, leadership, and PEBW, this research paves the way for more sophisticated theoretical models in organizational and environmental psychology.

In conclusion, these theoretical implications collectively enhance the level of sophistication and thoroughness in comprehending PEBW in the context of technological disruption. They extend existing theories, bridge gaps between disparate research streams, and provide a solid foundation for future investigations into the complex dynamics of organizational sustainability in an increasingly digital world.

Practical implications. The current study has valuable practical implications for top-level management teams and executives, and practitioners navigating the complex intersection of artificial intelligence (AI) implementation, employee behavior, and organizational sustainability. These insights provide actionable strategies for fostering pro-environmental behaviors while managing the challenges associated with technological disruption.

The first key implication for organizations is the need for a strategic and employee-centric approach to AI implementation. The findings underscore the potential harmful influences of AI-induced job insecurity on PEBW, highlighting the importance of carefully considering the human implications of AI adoption alongside technological and operational benefits. Top management teams should develop comprehensive change management strategies that address employee concerns about job security during AI implementation, aligning with research by Brougham and Haar (2020) on managing employee perceptions during technological transitions. Implementing transparent communication protocols is crucial to keep members informed about AI activities, their potential impacts, and the organization's plans for workforce adaptation. Such clear communication can help mitigate uncertainty and reduce perceptions of PCB (Morrison & Robinson, 1997).

The second practical implication stems from the study's findings on the mediating effect of PCB, emphasizing the importance of actively managing employee expectations and perceptions of organizational duties in the AI era. Organizations should regularly assess and realign psychological contracts to reflect the changing nature of work in AI-enhanced environments. This may involve explicitly addressing expectations around job roles, skill development, and job security in the context of AI adoption (Coyle-Shapiro et al., 2019). Developing policies and practices that demonstrate organizational commitment to employee well-being and career development, even as AI technologies are integrated into work processes, can help maintain a positive social exchange relationship and encourage reciprocal pro-environmental behaviors (Cropanzano & Mitchell, 2005).

Third, the moderating effect of ethical leadership on the relationship between AI-induced job insecurity and PCB has significant practical implications. This finding suggests that ethical leadership practices, such as transparent communication about AI implementation and demonstrating concern for employee well-being, can mitigate the negative effects of AI-induced job insecurity on psychological contract perceptions. For instance, leaders who openly discuss the potential impacts of AI

on job roles and provide opportunities for skill development may help maintain the psychological contract, even in the face of technological uncertainty.

Our findings extend previous research on job insecurity and pro-environmental behaviors. While previous works like Shoss et al., 2023 reported direct relationships between job insecurity and organizational citizenship behaviors, our results reveal a more complex picture. The non-significant direct path from AI-induced job insecurity to PEBW ($\beta = -0.048, p > 0.05$), coupled with the significant indirect effect through PCB, suggests that the impact of job insecurity on pro-environmental behaviors is more nuanced than previously thought. This aligns with recent calls in the literature for more complex models of employee behavior in the face of technological change (Brougham & Haar, 2018). Furthermore, our study is among the first to empirically demonstrate the role of ethical leadership in the context of AI-induced job insecurity. While Brown and Treviño (2006) have established the general importance of ethical leadership, our findings specifically show its buffering effect in technological transitions. This contributes to the literature on leadership in this digital age (Shrestha et al., 2019).

The fourth practical implication derives from the study's comprehensive theoretical framework, suggesting the need for a holistic approach to organizational sustainability that integrates technological, human, and environmental considerations. Organizations should develop cross-functional teams that bring together expertise in AI implementation, human resources, sustainability, and ethics to ensure a balanced approach to organizational initiatives. Implementing sustainability scorecards or key performance indicators (KPIs) that include measures of AI adoption, employee well-being, and environmental performance can help organizations track progress across multiple dimensions of sustainability (Epstein, 2018).

Fifth, our findings suggest several specific leadership practices and organizational policies to mitigate AI-induced job insecurity and foster PEBW. Organizations should proactively redesign job roles to incorporate AI, clearly defining how human employees and AI will collaborate. This can reduce uncertainty and job insecurity, as demonstrated by companies like Accenture that have implemented 'Human-AI collaboration' workshops to help employees understand and adapt to their evolving roles (Wilson & Daugherty, 2018). Furthermore, organizations should create dedicated committees or task forces responsible for overseeing the ethical implementation of AI. These structures can help ensure that AI deployment considers employee well-being and job security, as exemplified by Microsoft's AI ethics review process, which involves cross-functional teams to assess the potential impacts of AI projects on various stakeholders, including employees (Floridi et al., 2018). Organizations can also link AI implementation to environmental sustainability goals, potentially increasing employee engagement in PEBW. For example, Google's DeepMind AI has been used to reduce energy consumption in data centers, a project that can inspire employees to consider AI's potential for environmental benefits (DeepMind, 2016). Additionally, organizations should ensure that AI-driven decisions, especially those affecting job roles or employment status, are transparent and explainable. This can help maintain trust and reduce perceptions of psychological contract breach, as demonstrated by IBM's development of AI explainability toolkits that provide clear explanations of AI-driven decisions to employees (Gunning & Aha, 2019). Lastly, establishing voluntary, employee-led groups focused on AI can provide a platform for employees to share concerns, learn about AI developments, and contribute ideas for ethical AI implementation, fostering a sense of involvement and potentially reducing job insecurity.

Sixth, while our study was conducted in South Korea, the implications of our findings may vary across different cultural contexts. For instance, the effect of ethical leadership on mitigating AI-induced job insecurity might be stronger in cultures with higher power distance, where leaders' behaviors have a more significant impact on employees' perceptions (Hofstede, 2001). Similarly, the relationship between psychological contract breach and PEBW might be influenced by cultural differences in individualism versus collectivism. In more collectivist cultures, employees might maintain pro-environmental behaviors despite perceived contract breaches due to a stronger sense of collective responsibility (Triandis, 1995).

Furthermore, the perception of AI-induced job insecurity itself might vary across cultures. In societies with stronger social safety nets or lifetime employment traditions, such as Japan, the impact of AI on job insecurity might be less pronounced (Kato & Kodama, 2018). Conversely, in countries with more fluid labor markets, like the United States, AI-induced job insecurity might have a more significant effect on employee attitudes and behaviors. Therefore, while our findings provide valuable insights, organizations operating in diverse cultural contexts should consider these cultural nuances when implementing AI and designing strategies to maintain psychological contracts and promote pro-environmental behaviors. Future research could explicitly examine these cross-cultural variations to provide more globally applicable insights.

Limitations and suggestions for future works. While this paper offers valuable perspectives on the relationships between AI-induced job insecurity, PCB, PEBW, and ethical leadership, it is crucial to recognize many constraints and suggest avenues for future investigation.

First, while our 3-wave time-lagged design offers several advantages over cross-sectional studies, it is not without limitations. First, the potential for attrition bias must be considered. Our final response rate of 48.21% suggests that a significant portion of initial participants did not complete all three waves. This attrition may have introduced bias if the characteristics of those who dropped out differed systematically from those who completed the study (Wolke et al., 2009). Moreover, the time gaps between data collection (5–6 weeks) may have influenced our results. While this interval was chosen to minimize common method bias and capture the dynamic nature of our constructs, it may not have been optimal for detecting all relevant changes. For instance, the effects of AI-induced job insecurity on psychological contract breach might manifest over a longer period, or conversely, might be more immediate and thus partially missed by our measurement intervals (Podsakoff et al., 2012).

Additionally, our study's timeframe coincided with the ongoing COVID-19 pandemic, which may have introduced confounding factors. The pandemic has accelerated digital transformation in many organizations, potentially amplifying AI-induced job insecurity. Simultaneously, it may have affected pro-environmental behaviors due to changed work arrangements (e.g., increased remote work). The contingent elements would have affected the results of this paper in ways that are difficult to isolate (Carnevale & Hatak, 2020).

Second, our study was conducted within the unique cultural confines of South Korea, thus constraining the extrapolation of our results to different cultural environments. The perception of job insecurity, the nature of psychological contracts, and the manifestation of pro-environmental behaviors can vary significantly across cultures (Rousseau & Schalk, 2000). Future research

should consider cross-cultural comparisons to examine how these relationships may differ in various cultural contexts. This could involve replicating the study in multiple countries or conducting a multi-level analysis that incorporates national culture as a higher-level factor influencing individual-level relationships (Tsui et al., 2007).

Third, while our study focused on ethical leadership as a moderating factor, other leadership styles or organizational factors may also play crucial roles in shaping the relationships we examined. Future studies could explore the moderating effects of transformational leadership, servant leadership, or green leadership on the link between AI-induced job insecurity and PCB or PEBW (Eva et al., 2019; Robertson & Barling, 2013). Additionally, investigating organizational-level factors such as organizational culture, climate for innovation, or environmental management systems could offer a more comprehensive knowledge of the contextual influences on the relationships (Norton et al., 2015).

Fourth, our measurement of AI-induced job insecurity, while adapted from established scales, may not fully capture the nuanced nature of job insecurity related to AI implementation. The rapid evolution of AI technologies and their varied applications across different job roles and industries suggest that a more fine-grained measure of AI-induced job insecurity might be necessary. Future research could develop and validate a more comprehensive scale that considers different aspects of AI-induced job insecurity, such as fears of job displacement, concerns about skill obsolescence, or anxieties about human-AI collaboration (Brougham & Haar, 2020; Nam, 2019).

Fifth, while our study examined PEBW as an outcome, future works can investigate a more diverse range of outcomes affected by AI-induced job insecurity and psychological contract breach. This could include other forms of organizational citizenship behaviors, job performance, innovation behaviors, or employee well-being (Zhao et al., 2007). Additionally, investigating potential positive consequences of AI implementation, including augmented job enrichment or new skill development opportunities, could offer a more balanced view on the impact of AI at work (Makarius et al., 2020).

Lastly, our study focused on individual-level perceptions and behaviors. However, the implementation of AI technologies often occurs at the team or organizational level. Future works can adopt a multi-level approach to delve into how team-level or organization-level AI implementation strategies influence individual-level perceptions of job insecurity, PCB, and subsequent behaviors (Kozlowski & Klein, 2000). This could involve collecting data from multiple sources in an organization, such as employees, team leaders, and senior management, to gain a more holistic understanding of the phenomena.

Addressing these limitations and pursuing these future research directions could significantly improve our knowledge of the complex interplay between technological advancements, employee perceptions, leadership, and PEBW. Future research could explore digital transformations beyond AI and their impact on PEBW. For instance, the increasing adoption of Internet of Things (IoT) technologies in workplaces presents an interesting avenue for investigation. IoT devices can provide real-time feedback on resource consumption, potentially influencing employees' environmental behaviors. Research could examine how this constant availability of environmental data affects PEBW and whether it interacts with factors like job insecurity or psychological contract breach (Marikyan et al., 2019).

Additionally, emerging forms of leadership, such as digital leadership or sustainable leadership, could be examined in relation to PEBW. Digital leadership, which emphasizes the ability to drive digital transformation while considering its human

implications, might have unique effects on how employees perceive and respond to technological changes in terms of their pro-environmental behaviors (Cortellazzo et al., 2019). Similarly, sustainable leadership, which explicitly incorporates environmental considerations into leadership practices, could have significant implications for PEBW and might interact differently with AI-induced job insecurity compared to traditional leadership styles (Suriyankietkaew & Avery, 2016).

Furthermore, future studies could adopt a multi-level approach to examine how team-level or organization-level AI implementation strategies influence individual-level perceptions of job insecurity, PCB, and subsequent behaviors. This could involve collecting data from multiple sources within organizations, such as employees, team leaders, and senior management, to gain a more holistic understanding of the phenomena (Kozlowski & Klein, 2000).

Lastly, given the rapid advancement of AI technologies, longitudinal studies spanning several years may offer precious perspectives into how the relationship between AI-induced job insecurity and PEBW evolves over time. Such studies could capture potential adaptation processes and long-term changes in employee attitudes and behaviors as AI becomes more integrated into work processes.

Conclusion

This study provides significant insights into the complex relationships between AI-induced job insecurity, psychological contract breach, pro-environmental behavior at work, and the moderating effect of ethical leadership. Our findings reveal that AI-induced job insecurity does not directly impact PEBW, but rather operates through the mediating mechanism of psychological contract breach. The strong positive relationship between AI-induced job insecurity and PCB, coupled with the negative relationship between PCB and PEBW, highlights the potential unintended consequences of AI implementation on organizational sustainability efforts. Importantly, our research demonstrates the crucial role of ethical leadership in mitigating the negative effects of AI-induced job insecurity on psychological contract perceptions. As organizations continue to grapple with the dual challenges of technological advancement and environmental sustainability, understanding these intricate relationships becomes increasingly critical for fostering a sustainable and technologically advanced workplace.

Data availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Author contributions

Dr. Byung-Jik Kim contributed by writing the original draft of the manuscript and participating in the conceptualization, data collection, formal analysis, and methodology. Dr. Julak Lee and Dr. Min-Jik Kim contributed to the conceptualization, analysis, revision, and editing of the manuscript. All authors contributed to the writing of the final manuscript and have read and agreed to the published version of the manuscript. All members of this research team contributed to the management or administration of this paper.

Competing interests

The authors declare no competing interests.

Ethical Approval

The survey conducted in this study adhered to the standards outlined in the Declaration of Helsinki. The Yonsei University Institutional Review Board granted ethical approval. Approval number: 202208-HR-2975-01 Date of approval: 2022. 08. 15 Scope of approval: All research variables in this study.

Informed Consent

Obtained. Every participant was provided with information about the objective and extent of this study, as well as the intended utilization of the data. The respondents willingly and freely participated in the study. Their identities were kept confidential, and their involvement was optional. Prior to participating in the survey, all subjects included in the study provided informed consent. Informed consent was obtained from March 2022 to April 2022 through the website of the research company (Macromil Embrain). The scope of the consent covered participation, data use, and consent to publish. Online explanatory statement and documents related to exemption from written consent. Since the explanatory statement requires consent three times, it was submitted on the first, second, and third questionnaires. By default, written consent was waived. The reason for this is as follows. This survey was conducted through Macromil Embrain, a research company that has the largest panel in Korea (25 years of experience in the industry). Individuals belonging to the panel of Macromil Embrain registered in the company's survey response system and agreed to provide their information and survey content. Then, they logged in to the system and responded to the survey. At this time, the research company announced the contents of the researcher's survey, and panels interested in the survey participated in the survey. Alternatively, the research company asked those who were qualified to participate in the survey (e.g., office workers at a domestic company) via e-mail or text message about their intention to participate in the survey. This process was conducted entirely online, and it was practically impossible to obtain the consent of the research subjects because the researcher did not know which panel would respond to the questionnaire. Sufficient voluntary participation in research was ensured, and explanations regarding the guarantee of withdrawal and suspension of participation were supervised by the aforementioned research company. A research company manages this company's website by asking for consent when an individual signs up and registers. When a person signs up for this company's service as a panel, these matters are explained in detail and consent is obtained. Only those who gave their consent participated in the survey. The condition for selecting study subjects was that they must have been adult employees working for domestic companies. If participants were adult employees working for a domestic company, there were no special conditions such as regular or non-regular workers. People excluded from the study were those who were not currently working or who did not have the intellectual ability to understand and respond appropriately to the questionnaire. Also, people with limited ability to give consent for research or those who were vulnerable were not included as research subjects. Only those panels who had voluntarily registered to participate in the survey with the research company (Macromil Embrain) took part in the survey. In particular, when issuing a recruitment notice, the general subject and risks of the study were noted, and personal privacy was ensured during recruitment. Steps were taken to ensure the protection and confidentiality of participants. We did not include vulnerable research subjects. Vulnerability could be judged voluntarily by survey respondents. In addition, only those who met the research company's criteria (mentioned above) could participate in the

survey. The process and contents of the second and third surveys were the same as in the first survey.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-024-04139-2>.

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