



OPEN The impact of platform leadership on employee deviant innovation in digital transformation enterprises

An-Jin Shie^{1,2,5}, En-Min Xu^{1,5}, Hongchun Li³, Guanghai Yang² & Yung-Fu Huang⁴✉

Platform leadership (PL) has been increasing in digital transformation enterprises. This study explores the effects, pathways, and boundary conditions of PL on employee deviant innovation (EDI). In this study, 444 valid questionnaires were collected from ten digital transformation enterprises. Using conservation of resources theory and digital leadership theory, we built a parallel mediation model in which PL influenced EDI through psychological safety (PS) and creative self-efficacy (CSE), and verified the moderating effect of digital leadership (DL). The empirical results are as follows: (1) PL positively impacts EDI. (2) PL positively influences PS and CSE. (3) PS and CSE positively contribute to EDI. (4) PS and CSE mediate the relationship between PL and EDI. (5) DL moderates the relationship between PL and EDI, as well as between CSE and EDI. This study departs from traditional leadership theories by examining a new leadership style, PL, to inspire deviant innovation behavior among employees in digital transformation enterprises. This reveals the influencing mechanisms and provides new theoretical support for leadership and innovation management.

Keywords Digital transformation, Platform leadership, Employee deviant innovation, Psychological safety, Creative self-efficacy

Abbreviations

AVE	Average variance extracted
CFA	Confirmatory factor analysis
CR	Composite reliability
CSE	Creative self-efficacy
DL	Digital leadership
EDI	Employee deviant innovation
PL	Platform leadership
PS	Psychological safety
ULCMF	Unmeasured latent common method factor
VIF	Variance inflation factor

The ongoing Fourth Industrial Revolution, characterized by the widespread application of digital technologies, has disrupted the business practices and models of many traditional enterprises. An increasing number of companies are beginning their journey towards digital transformation¹. As digital transformation continues to advance, and management concepts are continuously updated, entrepreneurs are increasingly focusing on the benefits of employee innovation can bring². Companies hope that employees will propose creative ideas and engage in innovative behaviors, thereby promoting the company to gain a competitive advantage³. However, in actual management situations, conflicts exist between employee innovation and organizational constraints. On the one hand, organizations encourage employees to enhance their innovation awareness and capabilities to achieve long-term development and prosperity. On the other hand, organizations may reject seemingly 'out-of-the-box' ideas because of factors such as strategic orientation, resource allocation, and industry regulations⁴. When employees perceive an idea as feasible and capable of improving organizational efficiency but lack formal support, they may engage in covert practices to implement the idea, leading to deviant innovation. The emergence of deviant innovations such as light-emitting diode lighting technology, tape-cutting machines, and

¹College of Business Administration, Huaqiao University, Quanzhou, China. ²International College, Krirk University, Bangkok, Thailand. ³Department of General Education, Chongqing College of Mobile Communication, Chongqing, China. ⁴Department of Marketing and Logistics Management, Chaoyang University of Technology, Taichung, Taiwan. ⁵An-Jin Shie and En-Min Xu contributed equally to this work. ✉email: huf@cyut.edu.tw; t1995034@o365.cyut.edu.tw

the Sogou browser suggests that when deviant innovations with reasonable goals and legitimate means achieve success, they may yield qualitative improvements to enterprises and society as a whole⁵.

Deviant innovation is a negative behavior that violates organizational norms, policies, and systems. It encompasses actions that extend beyond designated roles and typically exhibit intentionality and spontaneity⁶. Studies have indicated that over 80% of employees engage in innovation through deviant means within enterprises, with research and development (R&D) teams being particularly implicated. Specifically, 5–10% of employees within R&D teams have previously engaged in deviant innovation⁷. Therefore, employees exhibiting deviant innovation within organizations are inevitable. Existing research has found that transformational, paternalistic, and differential leadership can promote employee deviant innovation (EDI) behavior to varying degrees^{8–10}. However, as the degree of digital transformation intensifies, the organizational environment develops towards diversity and dynamism. Organizational management is trending towards flattening and decentralization, making the traditional “top-down” leadership style incompatible with the digital transformation environment¹¹. A new leadership style called platform leadership (PL) has emerged in response to this change.

PL refers to a leadership style in which leaders value shared endeavors between themselves and their subordinates and are willing to build platforms for their subordinates to showcase their value, thereby unlocking their potential and achieving a win–win situation¹². During an enterprise’s digital transformation, platform leaders can provide digital platforms for employees to demonstrate their talent and actively collaborate with them¹³. This enables employees to gain critical resources and emotional support from their leaders who are highly likely to promote EDI.

Nevertheless, current research on PL primarily focuses on exploring the role, influence, and core responsibilities of platform leaders within teams, investigating how PL fosters collaboration and effective communication among team members, and analyzing how PL promotes team diversity and inclusivity to enhance team performance^{14–16}. For example, Xin et al.¹² developed a five-dimensional framework of PL—altruistic sharing, interactive collaboration, maker incubation, self-discipline and others-development, and equal empowerment—and examined its critical role in optimizing resource allocation and fostering member collaboration within teams. Leong et al.¹⁶ demonstrated that PL emphasizes the use of open platforms and resource sharing to inspire trust and interaction among team members, thereby effectively enhancing overall team performance.

However, research on the mechanisms by which PL influences EDI remains scarce, particularly in the context of enterprise digital transformation. No studies have yet examined the relationship between PL and EDI by incorporating the unique characteristics of digitalization. Therefore, our aim is to address the following theoretical gap: How does PL influence EDI in enterprises undergoing digital transformation?

To address the gaps in existing research, this study focuses on employees from enterprises that are undergoing or have completed digital transformation. For the first time, it integrates PL with DL capabilities to explore the pathways through which these leadership styles influence EDI. Grounded in conservation of resources theory and digital leadership (DL) theory, this study proposes and constructs a theoretical model to systematically explain how PL fosters EDI through empowerment and resource support, and how DL further moderates this relationship. The model is empirically tested using collected data to validate its theoretical assumptions. The research objectives are as follows:

1. Reveal how enterprises undergoing digital transformation can promote EDI through PL.
2. Provide organizations with management insights and strategies to enhance EDI.
3. Broaden and advance academic discussions in the fields of leadership and innovation and introduce new insights and methods for future exploration.

Theoretical foundations and research hypotheses

Direct relationship between PL and EDI

In organizational practice, leaders play a significant role in guiding employee behavior. As an emerging leadership style, PL creates opportunities for employees to unleash their innovative potential by building platforms for resource sharing and career development¹⁷. This leadership approach not only provides an open environment for innovation but also significantly enhances employees’ autonomy and willingness to explore through resource provision, support, and collaboration mechanisms¹⁸. Specifically, PL focuses on fostering an innovation-friendly atmosphere through empowerment and collaboration, supporting employees in taking bold initiatives and breaking traditional frameworks¹⁶.

On one hand, PL continuously optimizes the platform’s scale and resource allocation, offering employees ample space for development. This development platform not only increases the tools and opportunities available to employees but also stimulates their innovative potential through collaboration¹⁹. For example, leaders build innovation platforms that encourage knowledge sharing and collaboration among team members, creating a multidimensional support system for innovation. On this basis, employees’ creative behaviors are unleashed, gradually leading to a tendency for deviant innovation unconstrained by rules¹³. On the other hand, PL emphasizes mutual growth between individuals and the organization. When employees perceive the organization as a strong driver of resource provision, capability support, and collaborative trust, they are more likely to see themselves as “innovative agents” within the organization and engage more actively in innovation practices²⁰. This engagement is reflected not only in rule-compliant work but also in efforts to achieve breakthrough results through deviant behaviors²¹. Deviant innovation, as a legitimate-purpose but rule-deviating innovative behavior, can be significantly enhanced through the encouragement and resource support provided by PL. Hence, we propose the following hypothesis:

H1 PL has a positive impact on EDI.

Mediating role of psychological safety (PS)

According to conservation of resources theory, individuals facing complex and uncertain work situations can better cope with stress and achieve their goals by accumulating and preserving psychological resources²². PL, by creating resource-rich and open work platforms, provides employees with support and trust. This behavior effectively alleviates employees' concerns about potential negative consequences of innovation attempts¹⁶, thereby enhancing their PS. PS, as a state-based resource, helps mitigate the anxiety and unease individuals experience in the face of rule-breaking or failure risks at work, further promoting innovative behavior²³.

Carmeli and Gittell²⁴ reported that leadership behavior plays a significant role in influencing employees' PS. Leaders who exhibit positive and optimistic attitudes, resilience, and integrity are more likely to be perceived by employees as reliable sources of resources²⁵. PL, by emphasizing collaboration and mutual development with employees, enables them to feel a sense of support and trust¹⁴. Within the framework of conservation of resources theory, this sense of trust can be viewed as an external resource input that helps employees accumulate psychological resources²⁶, thereby strengthening their PS.

The role of PS in driving employee behavior has been widely validated. For example, Andersson et al.²⁷ highlighted that improved PS significantly enhances employees' innovative performance in high-risk contexts. EDI, a behavior that deviates from established norms but is directed toward organizational benefit, is often accompanied by higher uncertainty and potential failure risks²¹. Employees with high PS are more inclined to perceive these risks as manageable challenges rather than threats²⁸. This psychological confidence and openness not only enhance employees' interest in their work but also inspire them to explore new solutions beyond the existing rules²⁹.

Moreover, PS serves as a crucial bridge connecting PL and EDI. Conservation of resources theory emphasizes that individuals with sufficient psychological resources are more proactive and innovative in their behavior³⁰. PL provides employees with an open, resource-rich environment for innovation, fostering the confidence to overcome workplace challenges¹². This empowering leadership style not only supplies material resources but also delivers psychological resource inputs, thereby enhancing employees' PS. As a result, employees become more willing to take innovation risks and actively explore potential breakthrough pathways. For instance, studies have shown that when leaders demonstrate greater trust and support, employees are more confident in tackling challenges and more inclined to experiment with informal innovation methods, thus driving EDI^{21,31}. In this process, the resources provided by PL and the enhancement of PS form a positive cycle. By fostering an open and supportive innovation environment, leaders ensure employees feel adequately supported by the organization, thereby unleashing greater innovative potential²⁰. PS plays a pivotal role as a mediator in this chain, serving not only as a mechanism for translating resources into innovative behaviors but also as a core pathway through which PL effectively influences EDI. Thus, the following hypotheses are proposed:

H2 PL has a positive impact on employees' PS.

H3 Employees' PS has a positive impact on EDI.

H4 Employees' PS plays a mediating role between PL and EDI.

Mediating role of creative self-efficacy (CSE)

CSE refers to an individual's belief and confidence in their ability to generate value in innovation tasks³². This belief not only influences their enthusiasm for innovation but also determines their behavioral choices when facing resistance³³. According to conservation of resources theory, employees' psychological resources can be enhanced through external support, thereby fostering behavioral intentions and improving outcomes³⁴. In organizational contexts, PL significantly boosts employees' CSE through empowering behaviors. Specifically, PL emphasizes mutual development with subordinates, focusing on resource provision, creating opportunities for innovation, and fostering a culture of equal communication and trust¹⁶. These actions help employees feel that their innovative capabilities are recognized by the organization, thereby increasing their confidence in their own abilities. For example, Huang et al.³⁵ demonstrated that when leaders provide timely feedback and support employees in learning through trial and error, they significantly enhance employees' CSE. Furthermore, PL creates a supportive work environment and resource-rich platforms, equipping employees with greater psychological resources to face innovation tasks³⁶. This not only reduces their anxiety about failure but also further strengthens their sense of competence and confidence³⁷. As a result, PL positively influences employees' CSE through creative empowerment behaviors.

The enhancement of CSE directly drives employees' EDI. As a pro-organizational behavior, EDI requires employees to adopt flexible, and sometimes rule-breaking, approaches to achieve innovation goals, often involving high levels of uncertainty and risk³¹. Employees with high CSE tend to perceive rules as tools for optimizing innovation rather than constraints, making them more willing to actively push the innovation process by adjusting their behavioral strategies³⁸. Subramaniam and Youndt³⁹ suggested that an individual's belief in their innovative capabilities enhances their persistence in innovation scenarios, enabling them to focus more on breaking the status quo and creating value. Additionally, the motivational effect of CSE is evident in employees' greater inclination to experiment with new methods when faced with complex tasks, thereby facilitating deviant innovation¹⁰. Further studies have indicated that when employees perceive their innovation capabilities as strong, they are more likely to view innovation as a proactive choice rather than a passive response, making them more willing to take actions that transcend conventional norms^{40,41}.

CSE plays a pivotal mediating role in the relationship between PL and EDI. Conservation of resources theory emphasizes that individuals exhibit more proactive and creative behaviors when they have sufficient resources³⁴. By providing employees with a supportive environment and ample resources for innovation, PL enhances their

CSE⁴². This enhanced belief in their capabilities, in turn, drives employees to engage in more proactive and innovative behaviors, including rule-breaking deviant innovation⁴³. Through its empowering actions, PL helps employees accumulate psychological resources, which, when activated through CSE, make employees more willing to take innovation risks and explore new solutions⁴⁴. Through this mechanism, PL indirectly facilitates EDI. Consequently, the following hypotheses are proposed:

H5 PL has a positive impact on CSE.

H6 CSE has a positive impact on EDI.

H7 CSE plays a mediating role between PL and EDI.

Moderating role of DL

DL theory emphasizes that in a rapidly changing digital environment, leaders leverage digital technologies to redesign management practices, optimize resource allocation, and enhance collaboration, helping organizations and employees navigate complexity and uncertainty⁴⁵. PL is inherently deeply connected to digital technologies. By building innovation platforms, integrating organizational resources, and empowering employees, PL exemplifies the core characteristics of DL¹⁶. Specifically, PL employs digital technologies to promote information transparency, dynamic resource sharing, and efficient team collaboration, enabling employees to achieve greater autonomy and flexibility in their innovative practices⁴⁶.

Within the innovation environments created by PL, DL further amplifies the impact of PL on EDI through real-time feedback, collaborative tools, and data-driven resource management⁴⁷. For instance, leaders can utilize digital platforms for real-time monitoring and feedback, which not only helps employees adjust their innovation strategies more effectively but also alleviates frustration and stress arising from delays in information or resource mismatches during EDI⁴⁸. Studies have suggested that DL is particularly critical in complex task scenarios. By enabling efficient resource allocation and providing technological support, it allows employees to focus on breakthrough innovation tasks without worrying about external constraints^{46,49}. This technology-driven management approach amplifies the effects of PL's empowering behaviors, significantly enhancing the positive influence of PL on EDI. Thus, we propose the following hypothesis:

H8 DL plays a moderating role in the relationship between PL and EDI.

Furthermore, DL plays a significant moderating role in the relationship between CSE and EDI. CSE, defined as employees' confidence in their own abilities to perform innovation tasks, serves as a crucial psychological resource driving EDI⁵⁰. By leveraging technological empowerment, DL can further enhance the motivating effect of this psychological resource⁵¹. For example, DL uses real-time feedback tools to help employees promptly adjust their innovation trajectories and employs collaborative technologies to strengthen team support, ensuring that employees receive the necessary external resources and assistance during the innovation process⁵². This optimized environment boosts employees' confidence in tackling innovation tasks while mitigating anxiety caused by task complexity and the risk of failure.

From the perspective of conservation of resources theory, DL's technological support and environmental optimization safeguard and enhance employees' psychological resources⁴⁵, thereby amplifying the impact of CSE on EDI. DL serves as a bridge connecting organizational support with psychological resources. For instance, Gao and Gao⁵³ demonstrated that DL, through flexible work mechanisms and secure technological environments, enables employees to confidently apply creative thinking, break traditional rules, and take more proactive innovation actions. This further highlights that with the support of DL, the influence of CSE on EDI is significantly strengthened. Hence, we propose the following hypothesis:

H9 DL plays a moderating role in the relationship between CSE and EDI.

In summary, the theoretical model of this study is illustrated in Fig. 1.

Methodology

Data collection and sample analysis

In this study, we employed a widely used survey method in empirical research to collect data from employees of platform-based enterprises in Fujian Province, China. These enterprises have already undergone, or are currently undergoing, digital transformation. Data were collected using online questionnaires.

To begin with, we downloaded information on 350 enterprises listed in the 'Fujian Province Core Industries of the Digital Economy 2023 Annual Innovation Enterprise List,' available online. These companies, which exhibit digital transformation trends, span over ten advanced manufacturing and technology sectors, including semiconductors, computers, information services, new energy, pharmaceuticals, artificial intelligence, mechanical manufacturing, transportation, household appliances, and chemicals. Based on the principles of a high degree of digital transformation and strong platform characteristics (where companies can rely on certain platforms for operations and management), we selected 30 companies from the 350 companies that met the survey requirements. Of these, 10 agreed to participate in the survey. Subsequently, we obtained lists of all teams from the HR departments of these 10 companies, totaling 63 teams with 578 employees. Online questionnaires were coded accordingly.

To mitigate the common method bias, data were collected at two different time points. In the first survey, 578 questionnaires covering demographic information and PL variables were distributed. We received 514

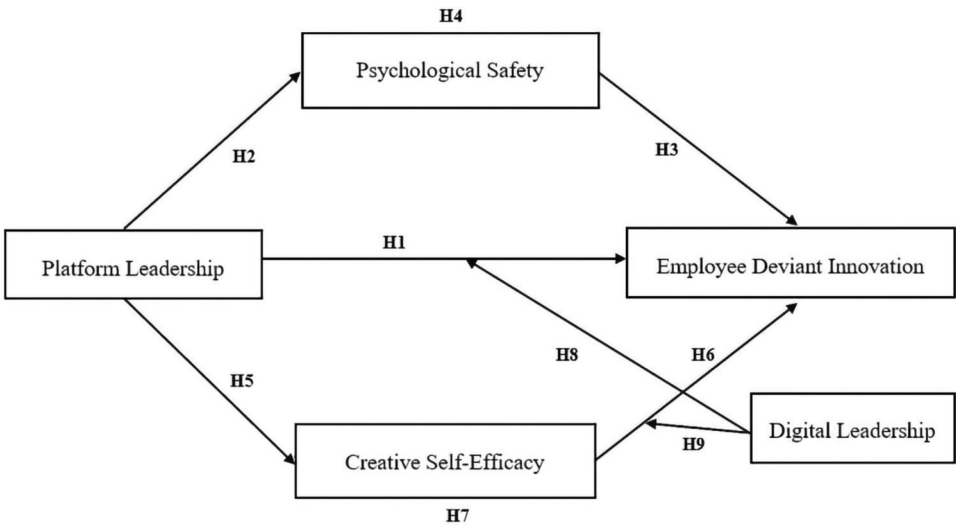


Fig. 1. Theoretical model.

Item	Category	Frequency	Percentage
Gender	Male	215	48.4
	Female	229	51.6
Age	Below 20	65	14.6
	21–30 years	221	49.8
	31–40 years	111	25.0
	41 years and over	47	10.6
Education	College and below	150	33.8
	Bachelor's degree	212	47.7
	Master's degree and above	82	18.5
Work experience	0–3 years	148	33.3
	3–6 years	120	27.0
	6–9 years	119	26.8
	9 years and above	57	12.8

Table 1. Sample characteristics.

completed questionnaires with a response rate of 88.9%. Two months later, we conducted a second survey by distributing questionnaires to the same employees that covered the PS, CSE, DL, and EDI variables. We sent 514 questionnaires and received 487 completed responses, a response rate of 94.7%. After excluding invalid responses (such as teams with fewer than three members and missing demographic information) and unmatched questionnaires from the two surveys, we obtained 444 valid responses from 56 effective teams, resulting in an overall effective response rate of 76.8%. This sample size is sufficient compared to similar previous studies^{10,21,54,55}, which typically range from 200 to 400 valid questionnaires.

The characteristics of the sample are listed in Table 1.

Measurement of variables

The five research variables in this study (PL, PS, CSE, DL, and EDI) were measured using scales developed by researchers in China and abroad. To ensure that the scale items are better aligned with the context of enterprise digital transformation and to enhance the relevance and contextualization of the measurements, this study incorporated digital characteristics into the scales while keeping the core content of the original items unchanged, and made localization adjustments to fit the actual context^{56,57}. In addition to the control variables, all the items within the research variable scale were measured using a five-point Likert scale. The variables were as follows:

PL We used the PL scale developed by Hao et al.¹⁴ and incorporated digital characteristics to obtain an 18-item scale.

EDI We adopted the EDI scale, which consists of nine items proposed by Lin et al.³¹.

PS We employed the measurement approach developed by Koopmann et al.⁵⁸ for team PS, and incorporated digital characteristics to obtain a six-item PS scale.

Model	CMIN	DF	CFI	TLI	RMSEA
Five-factor model (PL, CSE, PS, DL, EDI)	1397.035	1024	0.972	0.971	0.029
Single-factor model (PL + CSE + PS + DL + EDI)	4414.450	1034	0.748	0.737	0.086
Common method factor model (PL, CSE, PS, DL, EDI, ULCMF)	1302.332	977	0.976	0.973	0.027

Table 2. Fit indices for the measurement models.

Variables	Cronbach's	CR	AVE
PL	0.843	0.964	0.601
PS	0.852	0.891	0.578
CSE	0.856	0.886	0.565
DL	0.854	0.895	0.517
EDI	0.851	0.915	0.543

Table 3. Results of reliability and validity tests.

CSE We combined the definition of CSE by Chiang et al.⁵⁹ with the six aspects of innovation characteristics—sensitivity, fluency, flexibility, originality, redefinition, and insight—proposed by American psychologists Guilford and Hoffnarl. The scale also integrates digital platform features, resulting in a six-item CSE scale.

DL We adopted the six-item scale developed by Chatterjee et al.⁴⁷ and added two items to the original scale owing to the breadth of the study, resulting in an eight-item DL scale.

Control variables These included several demographic variables such as gender, age, education, and work experience.

Ethics statement

The study adheres to the principles outlined in the Declaration of Helsinki and approved by the Institutional Review Board of Huaqiao University.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Data analysis and hypothesis testing

Common method bias analysis

We adopted Harman's single-factor test and an unmeasured latent common method factor (ULCMF) to assess common method bias^{60,61}. The results obtained using SPSS 26.0 indicated that the first unrotated factor explained 43.7% of the variance. This value was less than the 50% benchmark⁶², suggesting no serious problem with common method bias. Moreover, the results of the confirmatory factor analysis (CFA) (see Table 2) showed that the fit of the five-factor model (CMIN/DF = 1.364, CFI = 0.972, TLI = 0.971, RMSEA = 0.029) was significantly better than that of the single-factor model (Δ CMIN = 3017.415, Δ DF = 10, $p < 0.001$), and the fit indices of the five-factor model did not differ from those of the measurement model with ULCMF (Δ CFI = 0.004, Δ TLI = 0.002, Δ RMSEA = 0.002). Together, we can conclude that the collected data were robust and reflective of the true relationships being studied, thus minimizing the risk of bias affecting the results.

Reliability and validity analysis

To assess the reliability and validity of the five variables in the research model, PL, EDI, PS, CSE, and DL, both SPSS 26.0, and AMOS 24.0, were used. The findings, summarized in Table 3, demonstrate that the Cronbach's α coefficients and Composite Reliability (CR) values for all five constructs surpassed the threshold of 0.8. This indicated a high level of reliability for each scale, suggesting that the measures used were consistent and dependable.

In addition, a confirmatory factor analysis was performed, and the findings are shown in Table 4. Every of the 47 items in the formal questionnaire achieved significant parameter factor loadings ($T > 1.96$, $p < 0.05$), with factor loadings above 0.5, and squared multiple correlations greater than 0.50. This indicates a strong correlation between the items within each construct. As highlighted in Table 2, the average variance extracted (AVE) for all five variables was greater than 0.5, confirming good convergent validity of the measurement model. Furthermore, the square root of the AVE for each variable exceeded its correlation with other variables, indicating the robust discriminant validity of the survey questionnaire.

Model fit analysis

Model fit indices were computed, and the results are presented in Table 5. The findings indicate that the CMIN/DF ratio was 1.367, falling within the acceptable range of less than 3. The RMSEA value was 0.029, indicating a small root mean square error that met the conventional criterion of less than 0.08. Additionally, other indices, including the GFI, NFI, IFI, CFI, PNFI, PCFI, and PGFI, all met or closely approached the required criteria. A comprehensive analysis of the results suggested that the various indicators of absolute, incremental, and

Scale	Scale items	SFL	SE	t	SMC
PL	(1) My leader allows subordinates to generate different views during the innovation process	1	–	–	0.811
	(2) My leader provides opportunities for subordinates to learn digital skills	0.825	0.045	18.22	0.753
	(3) My leader respects the personal characteristics presented by subordinates when using digital skills	0.834	0.046	18.28	0.754
	(4) When faced with bottlenecks in leading the team in digital transformation, my leader always encourages subordinates to maintain an optimistic attitude	0.902	0.044	20.67	0.823
	(5) My leader can promptly solve problems encountered by subordinates during the digital transformation process	0.854	0.046	18.693	0.767
	(6) When faced with problems in the digital transformation process, my leader thinks from different perspectives	0.85	0.043	19.832	0.8
	(7) My leader can quickly make decisions when faced with major decisions in the digital transformation of the enterprise	0.851	0.046	18.611	0.764
	(8) My leader treats subordinates equally during the digital transformation process	0.851	0.043	19.574	0.792
	(9) My leader believes that subordinates have the ability to use digital technology	0.804	0.044	18.274	0.754
	(10) My leader thinks that acknowledging subordinates' efforts in the digital transformation process is crucial for the enterprise	0.826	0.045	18.266	0.754
	(11) My leader leads the team to keep pace with the digital development needs of the industry	0.841	0.045	18.683	0.766
	(12) My leader can lead the team to achieve goals using digital technology	0.797	0.043	18.545	0.762
	(13) My leader has a strategic vision for the enterprise's long-term digital development	0.894	0.046	19.482	0.79
	(14) My leader encourages subordinates to expand their capabilities in the digital field through multiple channels	0.826	0.045	18.203	0.752
	(15) My leader encourages subordinates to solve problems using digital technology	0.865	0.044	19.76	0.798
	(16) My leader emphasises team cohesion during the digital transformation of the enterprise	0.809	0.042	19.08	0.778
	(17) My leader continuously improves personal skills in digital technology	0.828	0.045	18.442	0.759
	(18) My leader encourages communication among subordinates through digital platforms	0.867	0.046	18.997	0.776
PS	(1) In the team, my colleagues are tolerant of mistakes that occur at work	1	–	–	0.745
	(2) At work, everyone attempts to propose innovative ideas	0.983	0.062	15.78	0.754
	(3) In the team, everyone believes that using digital technology is advantageous for project progress	1.057	0.066	16.055	0.766
	(4) In the team, everyone can exchange information on the digital platform and collaboratively solve work problems	1.026	0.064	15.976	0.763
	(5) In the team, colleagues strongly support my use of using digital technology to complete assigned tasks	1.065	0.065	16.386	0.781
	(6) In the team, colleagues attach great importance to my digital skills	1.015	0.065	15.721	0.751
CSE	(1) I believe that my ability in digitalisation is beneficial to my career development	1	–	–	0.762
	(2) In the team, I can generate innovative ideas through the work summaries shared by everyone on the digital platform	0.938	0.061	15.424	0.726
	(3) I am good at summarising work using digital technology to improve work efficiency	1.039	0.064	16.119	0.756
	(4) I am good at using digital technology to analyse problems encountered during project execution	0.99	0.06	16.395	0.767
	(5) Digital technology can motivate me to accept new challenges	0.99	0.063	15.753	0.74
	(6) I want to use digital skills to improve traditional work methods	1.056	0.065	16.143	0.757
DL	(1) My leader believes that using digital skills at work is very efficient	1	–	–	0.712
	(2) My leader possesses a clear vision for the enterprise's digital transformation	0.959	0.067	14.219	0.712
	(3) In the development of the enterprise, my leader believes that promoting digital transformation is essential	1.016	0.071	14.323	0.717
	(4) My leader formulates corresponding reward policies for employees' digital innovation behavior	1.08	0.075	14.483	0.725
	(5) My leader formulates detailed plans for the digital transformation of the enterprise	1.03	0.072	14.34	0.718
	(6) My leader believes that digital transformation can bring more business opportunities to the enterprise	1.077	0.073	14.713	0.737
	(7) My leader pays close attention to the development trends in the digital field	1.022	0.072	14.221	0.712
	(8) Under the leadership of my leader, the enterprise has become a benchmark in the field of digital transformation	1.022	0.071	14.367	0.719
EDI	(1) During the project implementation process, I use digital technology extensively	1	–	–	0.707
	(2) I can use digital technology to compare information across related industries	1.063	0.074	14.351	0.714
	(3) I use my personal time to further improve and innovate projects that have not been adopted	1.117	0.075	14.953	0.745
	(4) I use working hours to innovate projects using digital technology	1.083	0.073	14.851	0.74
	(5) I am continuously expanding my own abilities, learning other skills in the digital field, and innovating in projects under my supervision	1.131	0.074	15.19	0.757
	(6) I constantly try to use digital technology to improve unexecuted plans	1.116	0.075	14.843	0.739
	(7) I actively apply digital technology to daily work	1.046	0.072	14.458	0.72
	(8) When using digital technology, it stimulates my innovative thinking in work	1.139	0.074	15.454	0.77
	(9) I continuously learn digital technology to ensure the feasibility of projects	1.071	0.072	14.865	0.74

Table 4. Confirmatory factor analysis of research model.

parsimonious fit largely met the criteria, indicating that the findings of this study can effectively represent the real-world conditions of the theoretical model.

Correlation analysis

Correlation analysis was performed among the variables, and the results are presented in Table 6. PL exhibited a significant positive correlation with PS, CSE, and EDI scores. Both PS and CSE exhibited significant positive

Fit index	Indicator	Criterion value	Parameters of this study	Compliance with criterion
Absolute fit	CMIN/DF	< 3.0	1.364	Yes
	RMSEA	< 0.10	0.029	Yes
	GFI	> 0.9	0.883	Close to criterion
Incremental fit	NFI	> 0.9	0.904	Yes
	IFI	> 0.9	0.972	Yes
	CFI	> 0.9	0.972	Yes
Parsimonious fit	PNFI	> 0.5	0.856	Yes
	PCFI	> 0.5	0.921	Yes
	PGFI	> 0.5	0.802	Yes

Table 5. Model fit indices.

Dimension	PL	PS	CSE	DL	EDI
PL	0.775				
PS	0.599**	0.760			
CSE	0.583**	0.577**	0.751		
DL	0.620**	0.554**	0.598**	0.719	
EDI	0.641**	0.614**	0.546**	0.557**	0.737

Table 6. Results of Pearson correlation analysis between variables. Diagonal values are the square roots of the AVE values of the corresponding variables. ** $p < 0.01$.

Dimension	VIF	1/VIF
PL	2.022	0.495
PS	1.840	0.544
CSE	1.898	0.527
DL	1.951	0.513

Table 7. Results of VIF values for explanatory variables.

correlations with the EDI. These preliminary findings support the study's hypotheses and prompt further regression analyses. Furthermore, a multicollinearity diagnosis was conducted to examine the explanatory variables in the model, and the results are presented in Table 7. The variance inflation factor (VIF) values for all explanatory variables were below 3⁶³, indicating the absence of multicollinearity issues. Therefore, the regression model in this study is stable and reliable.

Hypothesis testing

Tests of main and mediating effects

Hierarchical regression was employed to test the main and mediating effects among the variables. The results are presented in Table 8. To test the main effects, Model 5 represented the regression model of the control variables on EDI. Building on Model 5, Model 6 introduces PL, revealing a significant positive impact on EDI ($r = 0.644$, $p < 0.001$), thus confirming H1. For the testing of mediating effects, we examined the mediating effects of PS and CSE, with Models 2 and 4 testing the effects of PL on PS and CSE, respectively. The results show that PL has a significant positive impact on PS and CSE ($r = 0.581$, $p < 0.001$; $r = 0.602$, $p < 0.001$, respectively), confirming H2 and H5. Building on Model 6, Model 7 introduces PS, and the results demonstrate a significant positive impact on EDI ($r = 0.347$, $p < 0.001$), thus confirming H3. The coefficient of the effect of PL on EDI in Model 7 decreases from 0.644 to 0.435, suggesting that PS partially mediates the relationship between PL and EDI, thus confirming H4. Building on Model 6, Model 8 introduces CSE, and the results demonstrate a significant positive impact on EDI ($r = 0.256$, $p < 0.001$), thus confirming H7. The coefficient of the effect of PL on EDI in Model 8 decreases from 0.644 to 0.495, indicating that CSE partially mediates the relationship between PL and EDI, thus confirming H7.

Tests of moderating effects

In this section, we examined the moderating effects of DL. First, the variables PL, CSE, and DL were centered. Table 9 presents the results of the moderating effect tests. Models 9–12 sequentially introduce the control variables PL and DL and their interaction terms. The results indicated that the interaction terms of PL and DL had a significantly positive impact on EDI ($r = 0.071$, $p < 0.05$). This finding suggests that DL moderates the relationship between PL and EDI, thus confirming H8.

Variable	PS		CSE			EDI		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Gender	0.015	0.004	−0.011	−0.022	0.012	0	0.008	−0.001
Age	0.026	0.044	0.089	0.108	0.126	0.146	0.109	0.135
Education	−0.086	−0.058	−0.022	0.007	−0.045	−0.014	−0.016	0.001
Work experience	−0.05	−0.06	−0.039	−0.05	−0.062	−0.073	−0.056	−0.058
PL		0.581***		0.602***		0.644***	0.435***	0.495***
PS							0.347***	
CSE								0.256***
R ²	0.011	0.347	0.006	0.367	0.013	0.426	0.502	0.469
Adjusted R ²	0.002	0.34	−0.003	0.36	0.004	0.419	0.495	0.461
F	1.178	225.718	0.646	250.247	1.429	315.059	66.642	35.15

Table 8. Main and mediating effects tests results. Significant values are in [bold]. *** $p < 0.001$.

Variable	EDI						
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
Gender	0.012	0.000	−0.017	−0.024	−0.007	−0.03	−0.042
Age	0.126	−0.138	−0.091	−0.093	−0.106	−0.048	−0.042
Education	−0.045	0.015	0.018	0.010	−0.002	0.010	0.005
Work experience	−0.062	0.050	0.031	0.032	0.024	0.005	0.006
PL		0.601***	0.462***	0.448***			
CSE					0.527***	0.324***	0.309***
DL			0.245***	0.225***		0.361***	0.330***
PL × DL				0.071*			
CSE × DL							0.109**
R ²	0.013	0.426	0.459	0.464	0.307	0.383	0.395
Adjusted R ²	0.004	0.419	0.451	0.455	0.299	0.375	0.385
F	1.429	64.973	61.754	53.915	38.879	45.252	40.602

Table 9. Moderation effect test results. Significant values are in [bold]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

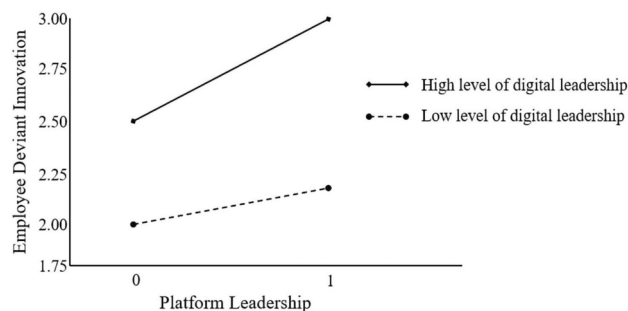


Fig. 2. Moderating effect of DL on the relationship between PL and EDI.

Furthermore, Models 9, 13, 14, and 15 sequentially introduce the control variables CSE and DL and the interaction term of CSE and DL. The results revealed that the interaction term between CSE and DL had a significantly positive impact on EDI ($r = 0.109$, $p < 0.01$). This implies that DL moderates the relationship between CSE and EDI, thus confirming H9.

To better understand the moderating effects of DL on the relationships between PL and EDI as well as between CSE and EDI, we created moderation effect diagrams (Figs. 2 and 3) and conducted simple slope analyses. Figure 2 illustrates that the slope under a high DL was noticeably steeper than that under a low DL. This indicates that when DL is stronger, the influence of PL on EDI becomes more significant, confirming the positive moderating effect of DL on this relationship and supporting Hypothesis H8. Similarly, Fig. 3 shows that the slope for high DL was steeper than that for low DL, suggesting that higher levels of DL amplify the effect of CSE on EDI. Thus, DL strengthens the positive relationship between CSE and EDI, confirming H9.

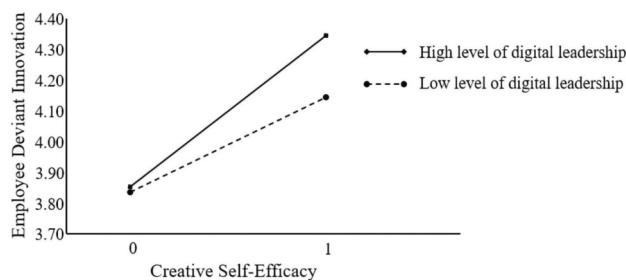


Fig. 3. Moderating effect of DL on the relationship between CSE and EDI.

Conclusion and discussion

Research findings

Drawing on conservation of resources theory and digital leadership theory, this study explored how PL, PS, CSE, and DL influence EDI. The key findings are summarized as follows:

Positive impact of PL on EDI

PL has been shown to significantly enhance EDI. This conclusion aligns with the findings of Hao et al.¹⁴, which highlight the positive impact of PL on employees' innovative work behaviors. It also resonates with research on other "bottom-up" leadership styles, such as humble leadership⁶⁴, empathetic leadership⁶⁵, and inclusive leadership⁶⁶, which have been demonstrated to effectively foster EDI. As a leadership style centered on inclusivity, resource sharing, and mutual growth, PL has shown substantial influence in modern workplaces, especially as younger generations increasingly value autonomy, independence, and freedom in their work environments.

By building sustainable career platforms and open professional stages, PL grants employees greater autonomy and innovation space, enabling them to proactively explore new work methods and even reshape existing workflows to seek novel paths for organizational growth. This resource-empowering leadership approach not only motivates employees to break conventional boundaries but also enhances their confidence and ability to overcome challenges during innovation. The freedom to allocate resources and expanded autonomy provide employees with a heightened sense of control over their innovative activities while reducing their concerns about potential failures. Moreover, the inclusivity of PL further underscores its positive impact on EDI. By viewing employees' rule-breaking behaviors as opportunities for innovation and recognizing and supporting such behaviors, PL provides employees with practical assurance to engage in EDI. This inclusive culture fosters the possibility of EDI, encouraging employees to break away from traditional constraints and actively drive new solutions, thereby injecting vitality into the organization's continuous development.

Mediating roles of PS and CSE

PS and CSE play critical mediating roles in the relationship between PL and EDI. On one hand, PL fosters PS by respecting individual differences and creating an inclusive and open environment. This heightened sense of PS significantly reduces employees' concerns and apprehensions about engaging in EDI, thereby encouraging their active participation in deviant innovation. This finding aligns with the research of Binyamin et al.⁶⁷, which demonstrates that PS enhances employees' innovative behaviors. It also resonates with studies suggesting that PL, through psychological support, creates a safe environment for employees, thus promoting innovation^{6,68}. Moreover, as an intrinsic psychological resource, PS encourages employees to actively experiment when confronted with complex tasks and rule boundaries, aligning with findings by Tu and Lu⁶⁹ that intrinsic psychological motivation is a key driver of innovative behavior.

On the other hand, PL enhances employees' innovative abilities and creative confidence through empowerment and resource support, motivating them to engage in breakthrough EDI. This conclusion aligns with the findings of Jaiswal and Dhar³³, which indicate that CSE strengthens employees' persistence and flexibility in innovation. Furthermore, CSE has a significant influence on employees' EDI. Employees with higher CSE are more likely to proactively explore new methods and pathways, even breaking conventional rules to achieve innovation. This conclusion complements existing literature on the mechanisms by which self-efficacy influences innovative behavior⁷⁰.

Moderating roles of DL

DL plays a significant moderating role in the relationships between PL and EDI, as well as between CSE and EDI. In the relationship between PL and EDI, the technological empowerment effect of DL is fully demonstrated. By integrating resources, providing real-time feedback, and enhancing collaboration efficiency, DL creates a more supportive and efficient environment for employees to engage in EDI. This study finds that such technological support amplifies the positive effects of PL, particularly in optimizing resource acquisition and innovation efficiency, echoing existing literature on the potential of DL to enhance organizational innovation. For instance, the research by Benitez et al.⁴⁶ highlights how DL, through empowerment and feedback mechanisms, reduces uncertainty in innovation and provides critical support for employees to engage in innovative behavior.

Similarly, DL significantly moderates the relationship between CSE and EDI. By improving resource accessibility and transparency, DL enhances employees' confidence in their abilities, thereby strengthening

the driving effect of CSE on EDI. This finding aligns with the conclusions of Fatima and Masood⁷¹, which suggest that technology-empowered leadership reduces employees' psychological burdens and increases their enthusiasm for innovation.

Theoretical contributions

The theoretical contributions are three-fold. First, this study identifies PL as a critical antecedent of EDI, thereby extending research on the mechanisms by which leadership behaviors influence EDI. Leadership style, as a key situational factor affecting employees' proactive behaviors, has been the subject of numerous studies exploring the impact of various leadership styles—such as DL⁵⁴, transformational leadership⁸, and coaching leadership²¹—on EDI. However, as an emerging leadership style born from the platform economy, PL is uniquely positioned to provide more effective resource support and opportunities for EDI, yet it has received relatively little attention in existing research. Although prior studies have explored the influence of PL on behaviors such as employee bootleg innovation³⁷, harmonious innovation⁶, and proactive innovation⁶⁸, its impact on EDI, particularly within the context of enterprise digital transformation, remains underexplored. By incorporating the contextual perspective of digital transformation, this study delves into how PL, through empowerment and resource support, fosters EDI, thereby contributing to the theoretical understanding of the mechanisms linking PL and EDI.

Second, this study reveals the mediating effects of PS and CSE in the relationship between PL and EDI. While prior research has predominantly explored the formation mechanisms of EDI through perspectives such as social cognitive theory⁷² and intrinsic motivation theory⁷³, this study, grounded in conservation of resources theory, clarifies the internal mechanism by which PL fosters EDI through psychological resource empowerment. Existing literature primarily focuses on individual-level psychological variables (e.g., intrinsic motivation⁷⁴, psychological entitlement⁷⁵, and job autonomy⁵⁵) and social environmental factors (e.g., team motivational climate⁷⁶ and perceived organizational support³⁸) as mediating mechanisms to explain the pathways to EDI. In contrast, this study adopts a psychological resource perspective and identifies PS and CSE as critical mediators in the relationship between PL and EDI. By constructing a theoretical framework of “PL—psychological resources—EDI,” this study advances the understanding of how leadership styles influence EDI and further extends the application scope of conservation of resources theory from a psychological resource perspective.

Third, this study further highlights the critical moderating role of DL in the relationship between PL and EDI, thereby extending the application of DL in the domain of employee innovation behaviors. Existing research predominantly focuses on the impact of DL at the macro level, such as on organizational performance⁴⁷ and team dynamic capabilities⁷⁷, with limited attention given to its moderating role at the individual level in shaping EDI. This study finds that DL significantly enhances the positive effect of PL on EDI. Its technology-driven empowerment mechanisms further optimize the resources and opportunities provided by PL, amplifying the effectiveness of PL in fostering an innovative environment. Moreover, this study confirms the moderating role of DL in the relationship between CSE and EDI. Through the support and feedback enabled by digital technologies, DL not only strengthens employees' confidence in their innovation capabilities but also significantly enhances the impact of CSE on EDI. These findings deepen the integration of DL theory with conservation of resources theory and offer a novel perspective for exploring the interplay between leadership styles and psychological mechanisms.

Managerial insights

Based on the research findings, several managerial insights can be drawn.

Strengthen the cultivation and development of PL

Organizations should focus cultivating the innovative thinking abilities and openness of PL by providing relevant training and education. This includes imparting innovative thinking skills, fostering an open mindset, and encouraging leaders to appreciate employees' innovative ideas and behaviors. Platform leaders should empower employees with autonomy and creative spaces, providing them with opportunities to attempt new methods to showcase their creativity and imagination. This creates an environment that encourages EDI.

Emphasise and enhance employee PS

Organizations should cultivate a positive work environment that promotes and supports employees' mental well-being. Initiatives such as psychological counselling, organizing mental health activities, and strengthening communication between leaders and employees. Timely feedback and support should be provided to help employees overcome challenges during the innovation process and boost their confidence. Diverse channels of communication, such as employee feedback mechanisms and innovation suggestion boxes, should also be provided to allow employees to propose innovative ideas to management. This enhances their PS and hence promotes EDI.

Foster an innovation-friendly culture

Organizations should implement reward systems that incentivize employees to propose ideas, test innovative methods, and transform innovations into tangible business value. The provision of necessary resources, such as technological tools, financial support, and professional talent, helps employees actualize their innovative concepts. Enterprises can also establish dedicated platforms or online spaces for employees to share their innovation methods, experiences, and best practices. Establishing such a knowledge-sharing platform can break down information barriers, promote communication and collaboration among employees, and stimulate innovation. These measures aim to improve employees' self-confidence and self-efficacy, thereby encouraging them to engage in deviant innovation activities more proactively.

Build a digital culture

Leaders should invest in diverse digital training, including internal and external programs and online courses, to improve employees' digital skills and proficiency with digital tools.. Furthermore, establishing a digital collaboration platform can facilitate cross-departmental cooperation and knowledge-sharing. Such platforms should provide features, such as online communication, file sharing, and project management, to facilitate collaboration and communication. In summary, by providing digital tools and technology, establishing a digital culture, improving digital literacy, and supporting digital transformation, DL can exert a positive moderating effect, thereby enhancing the digital capabilities of platform leaders and employees, and driving EDI.

Research limitations and future research directions

Despite the valuable insights gained from this study, we acknowledge some limitations. The research scope was confined to enterprises in Fujian Province undergoing digital transformation, and did not include enterprises from other countries or provinces, which may affect the generalizability of the findings. Additionally, subjective differences in respondents' perceptions and experiences when completing the questionnaire may introduce measurement errors.

Future research directions could also consider the following aspects:

1. EDI measurement was based on the subjective judgement of the participants. Future studies should incorporate leaders' measurements of EDI to improve the reliability and generalizability of the findings.
2. Future studies should involve detailed investigations and analyses of the relationship between PL and EDI at different stages of digital transformation, such as the introduction of digital technology, data-driven decision making, and business innovation. By comparing and analyzing the roles of PL at different stages of digital transformation, we can elucidate the means and mechanisms by which these roles affect EDI at different stages.
3. As this study focused on EDI, future studies should expand the scope of the investigation to include cross-level impacts. In addition to the mechanism by which PL affects EDI, it is important to consider its impact on innovative behavior at the team and organizational levels. For example, future studies could examine how PL influences the establishment of a team innovation climate and the cultivation of organizational innovation capabilities.

Data availability

Data is provided within the manuscript and its [Supplementary information](#) files.

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Author contributions

A.-J.S.'s and E.-M.X.'s contributions include: writing—original draft and revising, research conceptualization, methodology, communication with research objects, data collection, and data analysis. H.C.L.'s contributions include: research conceptualization, methodology, supervision, coordinating tasks, and writing—revising the manuscript. G.H.Y.'s contributions include: data collection, data processing, coordinating tasks, and writing—revising the manuscript. Y.-F.H.'s contributions include: research administration for the empirical project, resources, investigation, interpretation of data, writing—revising the manuscript, and final approval of the version.

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Competing interests

The authors declare no competing interests.

Additional information

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Correspondence and requests for materials should be addressed to Y.-F.H.

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