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# An understanding of sustainable transformational leadership and innovation ambidexterity: the mediating roles of social and psychological capital

## Abstract

This study investigates the complex interrelationships among sustainable transformational leadership (STL), psychological capital (PSY), social capital (SOC), and sustainable innovation ambidexterity (SIA) within China's manufacturing sector. Drawing upon social capital theory and positive organizational behavior frameworks, the research developed and empirically tested a comprehensive model examining direct and mediating relationships among these constructs. Data were collected from 520 employees across various hierarchical levels in Chinese manufacturing organizations. Utilizing partial least squares structural equation modeling (PLS-SEM), the findings reveal that STL is significantly associated with SIA, SOC, and PSY. Furthermore, SOC significantly predicts both PSY and SIA, while PSY is significantly associated with SIA. The study contributes to existing literature by holistically understanding how leadership practices foster sustainable innovation capabilities through social and psychological mechanisms. The findings provide valuable insights for manufacturing organizations seeking to enhance their sustainable innovation capabilities while maintaining operational efficiency in an increasingly sustainability-focused business environment.

**Keywords: Sustainable Transformational Leadership, Psychological Capital, Social Capital, Sustainable Innovation Ambidexterity, Partial Least Squares, Structural Equation Modeling**

## 1 Introduction

The modern business environment has seen an astonishing fusion of technological, industrial, and environmental aspects, reshaping how organizations operate. This shift has prompted progressive organizations to embrace environmentally responsible business practices (Demir et al., 2025). The emergence of Industry 4.0 in recent decades has positioned sustainability as a core strategic priority, marking what researchers identify as an environmentally focused industrial shift. Organizations are increasingly seeking eco-innovative solutions to climate change challenges, digital expansion, and sustainable energy development. Current market trends show growing consumer awareness of corporate environmental footprints, pushing organizations to position their environmental efforts as competitive advantages (Le & Gia, 2025). Research has thoroughly explored organizational management approaches for achieving market leadership. Studies recognize leadership practices as essential in building organizational commitment. In this setting, Sustainable Transformational Leadership (STL) is a key driver in improving employee outlook and organizational performance (X. Chen et al., 2025). STL leaders communicate sustainability initiatives through structured frameworks that outline strategic priorities and implementation approaches to achieve sustainability goals. These leaders demonstrate confidence and optimism, maintaining regular communication with staff about organizational sustainability targets while providing the necessary resources to achieve goals (Tho et al., 2025). With China's significant role in global manufacturing, studying the connection between

environmental considerations and innovation systems within these industrial organizations has become increasingly important (Zhou et al., 2019).

STL shares foundational elements with generic transformational leadership, including idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. STL represents a conceptually distinct leadership paradigm because it embeds a sustainability-oriented vision as its core ideological foundation, in which leaders articulate and champion environmental stewardship, social responsibility, and long-term ecological viability as non-negotiable organizational imperatives (X. Chen et al., 2025). In addition, STL leaders employ fundamentally different decision-making criteria when confronting performance-sustainability trade-offs, systematically prioritizing long-term environmental and social outcomes over short-term financial gains when conflicts arise. This decision logic is absent from traditional transformational leadership frameworks, which implicitly privilege economic performance (Demir et al., 2025). Therefore, this study examines STL as a theoretically distinct leadership construct that operates through sustainability-specific mechanisms.

Recent studies in organizational behavior highlight psychological capital (PSY) as a vital concept (Tho et al., 2025). Researchers define PSY as an integrated system that combines positive mental orientations, optimistic personality traits, and supportive organizational settings, thereby improving life quality while addressing life challenges (Su & Hahn, 2025). This approach focuses on building employee strengths rather than fixing weaknesses in management practices. PSY encompasses four key elements—optimism, resilience, hope, and self-efficacy—which enhance human capital, including personal skills and social capital within organizational networks (Njaramba, 2024). These psychological assets can be cultivated and used in much the same way as traditional organizational resources. The hope (HOP) element includes three core aspects: goal setting, path planning, and motivation in pursuing goals, showing clear organizational value and PSY growth. Optimism (OPT) identifies widespread impact and persistence as key features, which lead to greater workplace involvement and output. Resilience (RES) is the people's ability to handle situations effectively and protect themselves during difficult times. Lastly, self-efficacy (SEF) reflects people's belief in their ability to gather resources, maintain motivation, and direct effort needed to complete tasks in specific situations (Malik, 2024). Studies show a strong connection between STL and PSY, likely due to industry-specific factors. In manufacturing settings, where performance demands are high, workers seek leaders who offer creative solutions, direction, and assistance with organizational challenges (Malik, 2024). Research consistently shows that PSY's explanatory value is greater as a complete concept than as its separate parts. Research indicates that developing PSY improves organizational relationships (Alwali, 2024). Thus, this study aims to examine how STL affects employee PSY.

Studies show that sustainable innovation is key in shaping organizations' financial performance and sustainability results (Demir et al., 2025). March first introduced the concept of "ambidexterity," establishing the fundamental difference between exploitation and exploration activities (March, 1991). Organizations must balance these two aspects to avoid overreliance on existing exploitative methods while handling the risks of exploratory efforts. Research has explored ambidexterity's effects across different areas, including knowledge gathering, product development, supply chain management, and operational efficiency (Khan et al., 2021). This study expands the ambidexterity concept into sustainability. Sustainable innovation

ambidexterity (SIA) encompasses two primary aspects: sustainable exploitative innovation (SUSET), which enhances existing sustainability resources and knowledge, and sustainable exploratory innovation (SUSEP), which aims to develop new sustainable capabilities and knowledge structures (Chen, Chen, et al., 2024). In this area, STL creates effective models that build employees' psychological readiness, boost confidence in tackling challenges, and encourage goal-focused activities (X. Chen et al., 2025). This sustainability-focused change is significant for organizations, as it has a major impact on their operating environment (Demir et al., 2025). Understanding the links between innovation systems, environmental focus, green transition methods, perceived environmental uncertainty, and the ongoing role of STL becomes essential. Thus, this research aims to examine how STL relates to SIA.

Social capital (SOC), the sum of available or potential resources within social networks, has become a key factor in manufacturing industry success (Simmou et al., 2025). With their intricate supply chains and stakeholder connections, SOC helps share knowledge, lower transaction costs, and improve joint innovation abilities in today's manufacturing settings. In manufacturing firms, SOC appears in three primary forms: structural (network links), relational (trust and mutual exchange), and cognitive (shared outlook and principles), which together affect organizational results and sustainable innovation (Raza et al., 2024). The link between STL and SOC is of special importance, as transformational leaders shape and maintain social networks within and beyond organizational boundaries. Through their influence and motivation, sustainable transformational leaders build trust-based relationships and shared sustainability values among team members, while their attention strengthens interpersonal connections that boost SOC (Nauman et al., 2024). In manufacturing environments where environmental challenges require collective solutions, STL's ability to develop SOC becomes crucial for achieving sustainable innovation goals (Setiawan et al., 2021). Studying the relationship between STL and SOC is essential, as it reveals how leadership practices help build the organizational social resources needed for sustainable manufacturing. This understanding shows how manufacturing organizations can use STL skills to strengthen their SOC, helping their sustainable innovation capability and market position in an increasingly sustainability-focused business environment (Gashema & Kadhafi, 2020; Raza et al., 2024). Hence, this study aims to explore the relationship between STL and SOC.

Despite widespread recognition of sustainability's strategic importance, manufacturing organizations face a persistent dilemma that threatens their competitive viability. The simultaneous pursuit of sustainable innovation erodes short-term operational efficiency, yet exclusive focus on efficiency improvements undermines long-term innovative capacity necessary for sustainability transitions (Tang et al., 2022). This dilemma manifests clearly in China's manufacturing sector, where firms experience "paradoxical tensions": contradictory yet interrelated demands that cannot be resolved through simple trade-offs. Specifically, manufacturing organizations must engage in ambidextrous exploitative activities by maintaining rigorous process standardization, cost minimization, and quality consistency to preserve competitive efficiency. On the other hand, simultaneously investing in experimental sustainable technologies, tolerating innovation failures, and restructuring established routines to build innovative capabilities that directly conflict in their resource requirements, managerial attention, organizational structures, and performance metrics (Li et al., 2023). Empirical evidence reveals that manufacturing firms typically default to exploitation due to its predictable returns and immediate performance feedback, inadvertently creating "competency traps" that gradually erode

innovative capacity and leave organizations vulnerable to sustainability-driven market disruptions. Conversely, firms that overemphasize exploratory innovation experience resource depletion, operational instability, and efficiency deterioration that threaten near-term survival despite building long-term capabilities (Wang et al., 2025). The central challenge, therefore, is not whether to pursue innovation or efficiency, but rather understanding the organizational mechanisms, particularly leadership practices and employee-level resources that enable manufacturing firms to achieve SIA without experiencing debilitating resource conflicts or performance trade-offs (Tang et al., 2022). This study addresses this critical gap by investigating how STL cultivates PSY and SOC that enable employees to cognitively manage paradoxical demands, emotionally tolerate innovation-efficiency tensions, and behaviorally engage in both SUSET and SUSEP activities without experiencing role overload while sustaining efficiency-focused operations through human capital development rather than structural reconfiguration alone.

The complex connections between SOC, PSY, and SIA form key organizational patterns in today's business settings. SOC and PSY work together, with social networks and interactions strengthening individual psychological resources like SEF, OPT, and RES (Huang et al., 2021). This connection matters for this study because it shows how organizational social structures support the growth of psychological resources, leading to better employee well-being and performance (Xu et al., 2024). SOC also shows a strong positive link with SIA, as social networks facilitate knowledge sharing, resource acquisition, and joint innovation efforts (Simmou et al., 2025). Studying this relationship reveals how social resources help organizations pursue both exploratory and exploitative innovation work, creating lasting competitive benefits (Michalakopoulou et al., 2024). PSY directly affects SIA through better thinking abilities and innovative behaviors. People with stronger PSY manage the balance between exploratory and exploitative innovation more effectively (Lei et al., 2020). Understanding this relationship reveals how PSY enhances organizational innovation capabilities (Ullah et al., 2024). This deep understanding of how SOC, PSY, and SIA connect offers valuable insights for organizations seeking to enhance innovation by better managing social and psychological resources. Hence, this study aims to explore the association of SOC with PSY and SIA. Furthermore, the current study also aims to find the relationship between PSY and SIA.

This research advances both theoretical understanding and practical application in several ways. First, this study aims to explore the association of STL with PSY, SOC, and SIA. Secondly, this research aims to find the association of SOC with PSY and SIA. Lastly, this study aims to examine the relationship between PSY and SIA. For practitioners, this work offers valuable insights for manufacturing industry leaders in China and other regions, demonstrating how leadership practices can enhance both SOC and PSY, ultimately improving SIA results. These findings help organizations move toward sustainable operations while keeping their innovative edge. By studying these relationships in China's manufacturing sector, this research shows how Eastern cultural values and business practices shape sustainable innovation. Organizations can use these findings to create better leadership training programs and implement approaches that enhance SOC and PSY to achieve SIA. This work addresses the need for more comprehensive approaches to understanding how human and social factors drive sustainable innovation in today's organizations.

The hypothesized relationships among STL, PSY, SOC, and SIA are particularly salient in China's manufacturing context, given three distinctive institutional and regulatory features that create unique pressures and opportunities for sustainability-oriented organizational behaviors. First, China's increasingly stringent environmental regulatory regime imposes mandatory compliance requirements, substantial financial penalties for violations, and systematic environmental performance monitoring, fundamentally reshaping manufacturing firms' strategic priorities and innovation imperatives (Li et al., 2023). Unlike Western contexts where environmental regulations have evolved gradually over decades, China's regulatory tightening has occurred rapidly and comprehensively, creating acute adaptation pressures that demand simultaneous exploitation of existing compliance capabilities and exploration of novel sustainable concepts, precisely the SIA that this study examines (He et al., 2018). Second, China's manufacturing sector faces intense supply-chain sustainability pressures from multinational corporations and international buyers who impose stringent environmental standards as prerequisites, effectively making sustainability capabilities competitive necessities rather than voluntary initiatives (Shafique et al., 2024). These supply-chain pressures create what institutional theorists term "coercive isomorphism" (C. Chen et al., 2025), in which Chinese manufacturers must develop SIA capabilities to maintain access to global value chains, thereby amplifying the importance of STL practices that foster such capabilities through employee-level PSY and SOC. Third, China's institutional environment exhibits distinctive characteristics, including decisive government intervention, guanxi-based business networks, collectivist cultural values, and high power distance. These characteristics fundamentally shape how leadership influences employee behaviors and organizational outcomes (Xu et al., 2022). Moreover, China's collectivist culture emphasizes social harmony, group cohesion, and relational capital, making SOC a particularly potent mechanism for facilitating SIA in Chinese manufacturing organizations, compared to individualistic Western contexts, where formal structures may play a larger role (Simmou et al., 2025). The convergence of regulatory pressures, supply-chain demands, and cultural-institutional features creates a unique context wherein STL becomes critically important for manufacturing survival and competitiveness (X. Chen et al., 2025), PSY serves as an essential individual resource for managing sustainability-efficiency tensions (Tho et al., 2025), SOC functions as a culturally congruent coordination mechanism (Sun & Xu, 2025), and SIA emerges as a strategic imperative rather than a discretionary choice (Chen, Khan, et al., 2024). Therefore, while the theoretical relationships proposed in this study may hold across contexts, their magnitude, mechanisms, and practical significance are amplified in China's manufacturing sector by distinctive institutional and regulatory features, which justify the geographic focus and enhance the study's theoretical and practical contributions.

## **2 Literature Review and Hypotheses Development**

### **2.1 Sustainable Transformational Leadership and Psychological Capital**

Research literature has documented significant relationships between leadership practices and follower psychological attributes (Schuckert et al., 2018). Evidence suggests that PSY development responds positively to effective leadership interventions. The theoretical architecture of STL positions it as a significant facilitator of the four PSY dimensions: SEF, OPT, HOP, and RES (Njaramba, 2024). The foundational elements of STL, particularly exemplar behavior in vision articulation, encourage subordinates to pursue ambitious targets and anticipate positive outcomes (manifesting in OPT and HOP), develop task execution confidence

(reflecting SEF), and maintain persistence during adversity (demonstrating RES) (Malik, 2024). The management literature extensively documents empirical validation of STL's association with subordinate PSY (Alwali, 2024). Investigations established positive associations between perceived STL and subordinate PSY levels, confirming STL's role in enhancing follower PSY (Lester et al., 2024; Njaramba, 2024). These findings emphasize how STL's core attributes—vision articulation and alignment between individual and organizational goals—facilitate PSY development among subordinates. Thus, STL functions as a developmental mechanism across all PSY components, elevating aggregate follower PSY. This theoretical framework supports the following hypothesis:

H1. STL exerts a positive association with PSY.

## **2.2 Sustainable Transformational Leadership and Sustainable Innovation Ambidexterity**

STL initiates organizational transformation by modifying employee cognitive frameworks, belief structures, and value orientations. Research evidence demonstrates STL's contribution to innovation capabilities at both individual and organizational levels (X. Chen et al., 2025). The STL and SIA relationship manifests through the establishment of environments that encourage creative endeavors and experimental initiatives (Demir et al., 2025). STL's direct association with SIA has been documented through cognitive stimulation, vision communication, and an emphasis on innovation (X. Chen et al., 2025). Research has identified STL's role in developing organizational cultures characterized by creative thinking, strategic risk acceptance, and innovative solution generation (Huynh et al., 2024). In examining STL-SIA relationships, sustainable transformational leaders were established as crucial architects of innovation-supportive organizational environments. The literature indicates that STL practices build employee trust, facilitating knowledge exchange and optimizing the application of exploratory and exploitative knowledge to enhance SIA outcomes (Tang et al., 2022). Recent empirical work validates STL's efficacy in establishing conditions conducive to knowledge dissemination, thereby strengthening organizational SIA capabilities (Huynh et al., 2024). This body of evidence substantiates the positive association between STL and SIA.

H2. STL exerts a positive association with SIA.

## **2.3 Sustainable Transformational Leadership and Social Capital**

Sustainable transformational leaders demonstrate charismatic qualities and hold central positions within organizational advisory and influence networks, enabling direct interaction with team members for goal communication, barrier identification, consultation, and resource coordination (Raza et al., 2024). Individuals with well-developed SOC maintain productive relationships and networks with external entities that may possess valuable organizational knowledge. Fundamentally, STL encompasses cross-functional activities: monitoring external environments, engaging with external stakeholders, integrating relevant information and insights, and identifying strategic alternatives (Nauman et al., 2024). Through their motivational influence and role modeling, these leaders encourage employees to build external connections and develop their cross-functional capabilities. This process enhances SOC development as employees become more motivated to engage in cross-organizational information gathering, innovative risk-taking, experimentation, and external relationship building (Sienkiewicz-Małyjurek, 2022). Positional authority and charismatic influence provide STL practitioners with legitimacy and

access to key stakeholders and resources typically beyond the reach of employees, enabling them to secure government support and develop collaborative relationships with supply chain partners (Gashema & Kadhafi, 2020). Consequently, STL promotes cross-functional employee activities, enhancing social capital development.

H3. STL exerts a positive association with SOC.

## 2.4 Social Capital and Psychological Capital

Research literature consistently demonstrates that SOC and its elements are key factors in enhancing PSY and physical well-being among individuals, effectively minimizing adverse health outcomes (Xu et al., 2024). Strong social networks act as vital channels for sharing health-related information, encouraging the adoption of wellness-promoting behaviors (Liao et al., 2025). SOC also effectively decreases psychological pressure, supports mental health stability, and increases active engagement (Jiang & Shen, 2025). Moreover, social interactions amplify the shared benefits of collective activities, such as workplace wellness initiatives, sustaining participant involvement in these programs. These mechanisms enable SOC to foster individual health-oriented behaviors and improve employees' health-related quality of life (Zhang et al., 2024). Nevertheless, while the research confirms the relationship between SOC and PSY (Xu et al., 2024), the specific operational mechanisms require further investigation, especially regarding how strengthened SOC in manufacturing industry settings can enhance employees' PSY.

H4. SOC exerts a positive association with PSY.

## 2.5 Social Capital and Sustainable Innovation Ambidexterity

Research literature underscores SOC's vital role as a key driver of organizational innovation outcomes (Liao et al., 2025). Companies integrated within collaborative networks display enhanced green innovative capabilities. Research identifies a positive link between SOC and SIA (Simmou et al., 2025). SOC advances SIA primarily by reducing operational costs, including information search, communication, transactions, negotiations, and relationship monitoring expenses (Zirena-Bejarano et al., 2025). This support enables better access to knowledge, develops organizational identity, and builds trust-based relationships. SOC plays a vital role in knowledge acquisition and sharing processes. When organizations depend on external networks for knowledge development and innovative ideas, SOC provides access to essential resources and relationship networks that boost SIA (Al-Twal et al., 2024). It enables organizations to combine different types of knowledge from various stakeholders to achieve innovative results, thereby accelerating the SIA process (Manafe et al., 2024). Additionally, research confirms a positive relationship between an organization's SOC and SIA (Khan et al., 2021). Following this theoretical base, this study suggests that SOC positively affects SIA, leading to the following hypothesis:

H5. SOC exerts a positive association with SIA.

## 2.6 Psychological Capital and Sustainable Innovation Ambidexterity

Studies show that PSY significantly predicts organizational innovation capabilities. The components of PSY serve as key drivers of employee innovative behavior (Ullah et al., 2024).

This innovative behavior emerges as a vital element across organizational levels in supporting SIA, which remains essential for organizational effectiveness and efficiency (Tho et al., 2025). Research findings reveal that employees with strong expressions of the four PSY-RES, SEF, OPT, and HOP show greater SIA abilities in their technology use. These staff members demonstrate a greater capacity to envision, create, and implement breakthrough solutions in their technology applications. Studies examining PSY-SIA connections also reveal a notable association between PSY and SIA in the green construction industry (Tho et al., 2025). PSY development shapes how innovation is understood and organized. People with high PSY show better abilities to design and implement advanced solutions toward set goals (Lei et al., 2020). These individuals readily accept structural changes and create new approaches to achieve objectives (HOP), maintain confidence when adopting new behaviors (SEF), keep positive future expectations (OPT), and show flexibility toward organizational changes (RES). These qualities prove especially important for implementing innovative initiatives in green construction companies (Tang et al., 2022). This theoretical foundation suggests the following hypothesis:

H6. PSY exerts a positive association with SIA.

Figure 1. indicates the theoretical framework of the research.

[Insert Figure 1, here]

### **3 Methodology**

#### **3.1 Data Collection Procedure**

The investigation implemented a structured multi-stage sampling protocol to gather data from China's manufacturing sector workforce. The data acquisition phase occurred between April and May 2025, employing the Wenjuanxing digital survey platform. The sampling framework used a stratified sampling methodology, targeting respondents who met established selection criteria. To maximize sample representativeness, the initial phase involved stratifying China's manufacturing sector by primary industrial classifications defined by the National Bureau of Statistics of China. Subsequently, research partnerships were established with the China Federation of Industrial Economics and regional industrial complexes to facilitate survey distribution across diverse organizational hierarchies.

The sampling population comprised workforce members from manufacturing organizations registered with the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE). Following the stratified sampling design, these organizations were first categorized by industry subsectors and size classifications. The investigation employed a dual-phase data collection approach to minimize selection bias effects.

The initial phase involved proportional random selection of 200 manufacturing enterprises across the identified strata, followed by engagement with their respective Human Resource departments to facilitate the dissemination of survey links. The subsequent phase used established industrial networks and WeChat Work to engage individual employees directly, maintaining proportional representation across predetermined strata while ensuring comprehensive coverage of organizational hierarchical levels and functional domains.

To provide greater transparency regarding the employee selection process within participating firms, the following procedures were implemented. Of the 200 enterprises initially contacted, 156 firms (78% response rate at the firm level) agreed to participate through their HR departments. Within each participating firm, HR departments were provided with specific sampling quotas based on organizational size and hierarchical distribution. The obtained sample exhibited proportional distribution across organizational hierarchies: executive leadership (15%), intermediate management (35%), and operational personnel (50%). Participants' professional tenure in the sector averaged 8.5 years, suggesting substantial familiarity with organizational mechanisms and innovation methodologies.

HR departments were instructed to randomly select employees from their personnel databases in accordance with these predetermined quotas, ensuring representation across departments and tenure levels. Specifically, HR managers were asked to generate random employee lists using employee identification numbers and invite selected individuals via internal communication systems. This HR-mediated approach yielded 450 survey invitations, resulting in 312 valid responses.

The WeChat Work recruitment channel was implemented as a complementary strategy to enhance sample diversity and reduce potential HR selection bias. Through partnerships with industry associations and professional networks, survey links were distributed via WeChat Work groups comprising manufacturing sector employees. To maintain sampling integrity, respondents who accessed the survey through this channel were screened with qualifying questions about their employment status, organizational affiliation, and hierarchical position. This approach generated 300 survey invitations, yielding 208 valid responses. The data collection yielded 520 valid responses from 750 distributed instruments, achieving a 69.3% response rate. This sample size exceeds the structural equation modeling requirements outlined by Hair et al. (2010), who stipulate a minimum of 200 respondents for models examining 4-7 constructs.

The research instrument underwent preliminary validation through a pilot study involving 30 manufacturing-sector professionals, assessing instrument clarity and content validity. Their feedback facilitated refinements to enhance question comprehension and cultural relevance. The investigation incorporated multiple response quality assurance protocols: strategic placement of attention verification items throughout the instrument, minimum completion duration thresholds excluding submissions below 5 minutes, verification of unique IP addresses to prevent multiple submissions, and the incorporation of reverse-scored items to assess response consistency.

Regarding potential selection bias considerations, several limitations warrant acknowledgment. The HR-mediated distribution may introduce systematic bias if HR departments preferentially select employees with more favorable organizational perceptions or exclude specific employee categories. To mitigate this concern, HR departments received explicit instructions emphasizing random selection procedures and the importance of diverse representation. The WeChat Work channel, while potentially subject to self-selection bias (employees more engaged with professional networks may differ systematically from non-participants), provided a complementary sampling frame that partially offset HR-mediated limitations. Comparing demographic characteristics and key study variables between the two recruitment channels revealed no statistically significant differences ( $p > 0.05$ ), suggesting reasonable consistency

across the sampling approaches. Nevertheless, residual selection bias cannot be entirely eliminated, and findings should be interpreted with this limitation in mind.

### 3.2 Data Collection Instrument

The measurement instrument used in this investigation comprised a questionnaire that employed a seven-tier Likert-type scale to assess participants' levels of agreement with presented statements, extending beyond binary agreement indicators. The research instrument used a seven-point Likert-type scale to evaluate respondents' agreement with the provided statements. The scale ranged from 1 (complete disagreement) to 4 (neutral) to 7 (complete agreement).

The selection of the seven-point scale structure aligns with established psychometric research, which demonstrates optimal reliability and validity indices for scales containing five to seven response categories. While extended response formats, such as ten-point scales, enable greater response granularity, they may introduce unnecessary complexity and increase the risk of inconsistent responses. The seven-point configuration offered sufficient discriminatory capability while preserving measurement accessibility and practical utility (Khan et al., 2021).

The items to measure PSY were taken from Luthans, Youssef, and Avolio's (2007) research. STL was measured using items adapted and modified from Singh et al.'s (2020) study. SIA was measured using the items proposed by Khan et al. (2021). Lastly, SOC was measured by the items adapted and modified from Slåtten et al.'s (2019) research.

## 4 Data Analysis

The investigation employed a two-phase analytical procedure utilizing partial least squares (PLS) methodology. The initial phase encompassed the assessment of measurement validity and reliability indices, while the subsequent phase examined structural relationships and directional influences among theoretical constructs (Hulland, 1999). The adoption of the PLS methodology was predicated on its established efficacy in preserving theoretical construct relationships within complex research frameworks (Petter et al., 2007). This analytical framework demonstrates particular utility in scenarios involving non-normally distributed data by incorporating specialized randomization indicators. The study employed systematic analytical protocols (Chin & Newsted, 1999; Zhao & Khan, 2021) and PLS-SEM's inherent capability to evaluate multifaceted model architectures (Ringle et al., 2024).

### 4.1 Higher-Order Construct Specification

This investigation operationalized PSY and SIA as second-order reflective-reflective hierarchical constructs, following the conceptualization established in prior literature (Jarvis et al., 2003). For PSY, the four first-order dimensions—SEF, OPT, HOP, and RES—were modeled as reflective indicators of their respective latent constructs, which in turn serve as reflective indicators of the higher-order PSY construct. This specification aligns with theoretical foundations suggesting that these four dimensions are manifestations of an underlying PSY construct, where changes in the higher-order construct cause changes in the lower-order dimensions rather than the reverse (Luthans & Youssef-Morgan, 2017). Similarly, SIA was specified as a reflective-reflective construct comprising two first-order dimensions: SUSET and SUSEP (March, 1991). The reflective-reflective specification was selected based on several theoretical and empirical

considerations. First, the four PSY dimensions are theoretically interrelated and share a common conceptual core—positive psychological states that can be developed and leveraged for performance improvement (Luthans, Avolio, et al., 2007). Second, for SIA, both SUSEP and SUSET dimensions represent complementary manifestations of an organization's ambidextrous innovation capability rather than independent components that collectively define the construct (March, 1991).

The estimation of these higher-order constructs followed the repeated indicators approach (also known as the hierarchical component model) in SmartPLS 4 (Ringle et al., 2024). This method uses all indicators from the first-order constructs as indicators of the second-order construct, allowing direct estimation of path coefficients between the higher-order constructs and other variables in the structural model. For PSY, all items measuring SEF, OPT, HOP, and RES were assigned to the second-order PSY construct. For SIA, all items measuring SUSET and SUSEP were assigned to the second-order SIA construct. This approach has been validated in previous organizational behavior and innovation research employing PLS-SEM (Hair Jr et al., 2017) and provides reliable estimates of higher-order construct relationships while maintaining the theoretical integrity of the multidimensional constructs.

#### 4.2 Convergent and Discriminant Validity

Prior to evaluating the structural model, multicollinearity among indicator variables was assessed using the Variance Inflation Factor (VIF) analysis. High multicollinearity can lead to unstable parameter estimates, inflated standard errors, and difficulty in determining the individual contributions of indicators to their latent constructs. The results indicated in Table 1 reveal that all indicator VIF values range from 1.291 (RES2) to 2.637 (SUSET2), substantially below the critical threshold of 5.0 and even the more conservative threshold of 3.0 (Kock & Lynn, 2012). These consistently low VIF values across all constructs—PSY dimensions (HOP, OPT, RES, SEF), SIA dimensions (SUSEP, SUSET), sustainable transformational leadership (STL), and social capital (SOC)—confirm the absence of multicollinearity concerns.

In addition, factor loadings were calculated to represent the strength of relationships between indicators and their latent constructs. The results indicated in Table 1 indicate that the SOC construct's all loadings are above 0.713; STL exhibits loadings from 0.722 to 0.818; SUSET displays loadings from 0.730 to 0.875; and SUSEP shows loadings from 0.700 to 0.803. For the PSY dimensions, HOP ranges from 0.620 to 0.751, OPT from 0.662 to 0.743, RES from 0.596 to 0.758, and SEF from 0.617 to 0.734. All the indicators met the minimum acceptable threshold of 0.60 (Chin, 1998). These results confirm robust indicator-construct relationships and support the measurement model's reliability and validity.

Multiple evaluation criteria were implemented to verify convergent validity. Internal consistency was assessed using factor loadings and Cronbach's alpha, while reliability was assessed using rho\_A and composite reliability (CR). The rho\_A coefficient is a distinct reliability indicator that employs weight-based computational methods rather than loading calculations (Henseler et al., 2014). Methodological standards stipulate 0.7 as the minimum acceptable threshold for factor loadings, rho\_A, and Cronbach's alpha values (Van Nguyen & Habók, 2021). As illustrated in Table 1, all theoretical constructs met the 0.7 benchmark across CR, Cronbach's alpha, and rho\_A (Chin, 1998), substantiating the instrument's internal validity.

The Average Variance Extracted (AVE) represents the average amount of variance that a latent construct explains in its observed indicators relative to the amount due to measurement error. According to the AVEs indicated in Table 1, all constructs in this study surpassed this criterion. These values confirm that each construct captures substantially more variance from its indicators than can be attributed to measurement error, thereby establishing strong convergent validity (Fornell & Larcker, 1981).

[Insert Table 1, here]

The examination of discriminant validity focused on establishing the unique characteristics among theoretical constructs. This assessment implemented the analytical framework developed by Fornell and Larcker, which examines inter-construct relationships by computing Average Variance Extracted (AVE) square roots (Fornell & Larcker, 1981). The analytical outcomes presented in Table 2 establish robust construct differentiation, as the square root values of the AVEs (highlighted in bold) exceed the corresponding inter-construct correlation coefficients. These results verify that individual components exhibit stronger associations within their designated constructs than their relationships with external constructs.

[Insert Table 2, here]

Discriminant validity was further assessed in Table 3 using the Heterotrait-Monotrait (HTMT) ratio, which provides a more stringent evaluation than traditional approaches. Following the threshold of 0.85 for conceptually distinct constructs and 0.90 for related constructs (Franke & Sarstedt, 2019; Henseler et al., 2015), the results in Table 3 demonstrate adequate discriminant validity across all construct pairs. While several HTMT values approach or slightly exceed 0.85—particularly among PSY dimensions (SEF-OPT: 0.892; SEF-RES: 0.871; SEF-HOP: 0.870; RES-HOP: 0.868) and between SIA and their antecedents (SUSEP-STL: 0.883; SUSEP-SOC: 0.856)—these elevated values are theoretically justified given that PSY dimensions represent facets of a higher-order construct (Luthans, Avolio, et al., 2007) and innovation capabilities are conceptually proximal to their leadership and social capital antecedents (Tang et al., 2022).

[Insert Table 3, here]

Additional verification of discriminant validity was conducted through a confidence interval (CI) examination. The investigation employed bootstrapping with 5000 resamples to estimate 95% confidence intervals for inter-construct correlations. The analytical outcomes in Table 4 demonstrate that all confidence intervals excluded 1.0, with the maximum upper boundary observed at 0.770 in the STL -> SUSEP relationship. These statistical findings provide additional evidence of the discriminant validity of the theoretical constructs (Torkzadeh et al., 2003).

[Insert Table 4, here]

### 4.3 Hypotheses Results

The structural model assessment proceeded through sequential regression analysis implemented via the SmartPLS platform (Ringle et al., 2024). This investigation phase focused on internal model calculations, in which hypothesized relationships were verified by examining statistical

significance indicators, specifically t-statistics and p-values. The complete statistical findings derived from these analytical procedures are documented in Table 5 and Figure 2.

First, STL demonstrates a substantial association with PSY ( $\beta = 0.367$ ,  $t = 6.863$ ), confirming that leaders who articulate sustainability visions, prioritize environmental outcomes, and allocate resources toward green initiatives systematically cultivate employees' HOP, OPT, RES, and SEF—the psychological resources necessary for managing innovation-efficiency tensions. This finding validates the proposition of positive organizational behavior theory that leadership practices shape employees' cognitive-emotional states, which subsequently predict their capacity to engage with complex, paradoxical work demands (Luthans et al., 2007).

Second, STL has a significant association with SIA ( $\beta = 0.433$ ,  $t = 9.057$ ), demonstrating that sustainability-oriented leadership not only associates with employee psychological states but also directly stimulates both SUSEP (developing breakthrough sustainable solutions) and SUSET (refining existing sustainable practices). This association suggests that STL provides the strategic direction, resource support, and normative climate necessary for employees to pursue SIA activities without experiencing debilitating role conflicts.

Third, the firm relationship between STL and SOC ( $\beta = 0.677$ ,  $t = 20.734$ ) reveals that sustainability-focused leaders fundamentally reshape organizational social structures by fostering trust networks, facilitating knowledge exchange, and building collaborative relationships. SOC is, in turn, significantly associated with both PSY ( $\beta = 0.368$ ,  $t = 6.817$ ) and SIA ( $\beta = 0.362$ ,  $t = 7.975$ ), confirming SOC theory's assertion that relational resources provide informational benefits and emotional support that enhance individual psychological states and collective innovation capabilities (Nahapiet & Ghoshal, 1998).

Finally, PSY is significantly associated with SIA ( $\beta = 0.126$ ,  $t = 2.694$ ), indicating that employees with higher HOP, OPT, RES, and SEF possess the cognitive flexibility and emotional stamina to engage in both SUSEP experimentation and SUSET refinement—the dual innovation behaviors that constitute ambidexterity.

[Insert Table 5, here]

[Insert Figure 2, here]

Table 6 indicates the indirect relationships of the study. Regarding SOC as a mediating construct, STL indirectly predicted PSY ( $\beta = 0.249$ ,  $t\text{-value} = 6.597$ ) and SIA ( $\beta = 0.245$ ,  $t\text{-value} = 7.217$ ). Furthermore, SIA was indirectly associated with SOC ( $\beta = 0.047$ ,  $t\text{-value} = 2.401$ ) and STL ( $\beta = 0.046$ ,  $t\text{-value} = 2.410$ ) while having PSY as the mediating construct. Lastly, STL was found to indirectly associated with SIA ( $\beta = 0.032$ ,  $t\text{-value} = 2.374$ ) while having chain mediation of SOC and PSY.

[Insert Table 6, here]

Table 7 presents the structural model's effect size and predictive accuracy metrics, demonstrating its explanatory and predictive capabilities. The  $R^2$  values for PSY (0.452) and SOC (0.458)

indicate moderate explanatory power, while the  $R^2$  for SIA (0.671) indicates substantial explanatory power, indicating that the model effectively captures the variance in sustainable innovation ambidexterity. The minimal differences between  $R^2$  and adjusted  $R^2$  values (ranging from 0.002 to 0.002) confirm model significance and suggest that the inclusion of predictor variables is justified without overfitting concerns (Hair Jr et al., 2017).

Additionally, Table 7 presents the Stone-Geisser  $Q^2$  values, obtained through the blindfolding procedure, which provide evidence of the model's predictive relevance. All endogenous constructs exhibit positive  $Q^2$  values (PSY = 0.300, SOC = 0.276, SIA = 0.450), exceeding the zero threshold and confirming that the model predicts better than the mean (Geisser, 1974; Stone, 1974). Furthermore, the  $Q^2$  predict values (PSY = 0.373, SOC = 0.455, SIA = 0.571) exceed the corresponding  $Q^2$  values, indicating robust out-of-sample predictive power and supporting the model's generalizability (Shmueli et al., 2016).

The  $f^2$  effect-size analysis in Table 7 reveals varying degrees of predictor importance in explaining the endogenous constructs. According to Cohen's (1988) thresholds, 0.02 is deemed small, 0.15 medium, and 0.35 large. For PSY, both STL ( $f^2 = 0.133$ ) and SOC ( $f^2 = 0.134$ ) demonstrate small-to-medium effects, suggesting comparable contributions to PSY development. In predicting SOC, STL exhibits a large effect ( $f^2 = 0.843$ ), indicating that STL is a critical determinant of SOC. For SIA, STL demonstrates a medium effect ( $f^2 = 0.275$ ), SOC shows a medium effect ( $f^2 = 0.192$ ), while PSY exhibits a small effect ( $f^2 = 0.026$ ). These findings suggest that while all three predictors contribute to SIA, STL and SOC play more substantial roles compared to PSY. Collectively, these results demonstrate that the structural model possesses robust explanatory power and predictive relevance, with STL emerging as a particularly influential driver of both SOC and SIA in China's manufacturing sector.

[Insert Table 7, here]

Model fit assessment was conducted using indices appropriate for PLS-SEM analysis. The Standardized Root Mean Square Residual (SRMR), the primary goodness-of-fit measure in PLS-SEM, yielded a value of 0.097, which falls below the recommended threshold of 0.10 (Henseler et al., 2014), indicating acceptable model fit. Overall, the SRMR values confirm adequate model fit, supporting the appropriateness of the theoretical framework for examining the relationships among STL, SOC, PSY, and SIA.

#### **4.4 Importance-performance map (IPMA)**

To complement the structural model findings, this research conducted an Importance-Performance Map Analysis (IPMA) to assess each construct's relative significance and actual performance. IPMA extends the traditional PLS-SEM analysis by integrating latent-variable scores, thereby providing deeper analytical insights (Hair et al., 2019). This analytical approach has gained traction in recent literature for its ability to identify critical improvement areas by simultaneously evaluating construct importance and performance dimensions (Sarstedt et al., 2024).

The IPMA results, shown in Table 8 and Figure 3, reveal distinct patterns across the examined constructs. The IPMA reveals PSY exhibits the highest performance score (68.857) yet demonstrates comparatively low total importance (0.124). This apparent paradox can be

explained through three interconnected theoretical mechanisms. First, PSY primarily operates through indirect pathways via SOC rather than exerting strong direct associations on SIA. The structural model confirms this interpretation—while PSY is significantly associated with SIA ( $\beta = 0.126$ ), its association is substantially smaller than SOC's direct association ( $\beta = 0.362$ )—suggesting that psychological resources require social infrastructure to manifest their full innovation-enabling potential, consistent with SOC theory's proposition that relational resources provide structural conduits through which individual psychological states translate into collective outcomes (Nahapiet & Ghoshal, 1998).

Second, the high PSY performance coupled with low incremental importance likely indicates diminishing marginal returns—once employees achieve threshold levels of HOP, OPT, RES, and SEF, additional investments in PSY development yield progressively smaller performance improvements. This phenomenon aligns with resource-based theory's concept of resource saturation, in which organizational capabilities exhibit nonlinear performance relationships (Barney, 1991). Empirical evidence from positive organizational behavior research supports this interpretation, demonstrating that PSY's benefits plateau after reaching moderate-to-high levels (Luthans, Avolio, et al., 2007).

Third, and most critically for China's manufacturing context, institutional and organizational factors may exert stronger direct influence on SIA than individual-level PSY. Environmental regulations, supply-chain sustainability pressures from multinational buyers, and corporate governance mechanisms create structural imperatives that shape innovation patterns independently of employees' psychological states (Tang et al., 2022). These macro-level forces establish compliance requirements, resource constraints, and performance expectations that directly determine SIA priorities, potentially explaining why PSY's total importance remains modest despite high performance levels.

The exceptionally high importance of STL (0.756), combined with its lowest performance (60.362), confirms that leadership practices represent the critical leverage point for enhancing SIA. This finding reveals a strategic misalignment; while organizations have successfully developed employees' PSY, they have underinvested in cultivating sustainability-focused leadership capabilities. Given SOC's balanced importance-performance profile (importance = 0.409, performance = 63.059), the IPMA results indicate a strategic reallocation of resources.

Organizations should prioritize leadership development initiatives that enhance managers' sustainability knowledge, environmental decision-making competencies, and ability to articulate compelling sustainability visions, while maintaining current PSY. Simultaneously, investments in network-building initiatives like cross-functional teams, knowledge-sharing platforms, and collaborative innovation projects can strengthen the relational infrastructure through which both STL and PSY translate into SIA outcomes (Nahapiet & Ghoshal, 1998).

[Insert Table 8, here]

[Insert Figure 3, here]

## 5 Discussions

### 5.1 Comparison of Results

According to the present research, STL is significantly associated with PSY. This result can be compared with an earlier study by Njaramba (2024). Their study delved into the distinct effects of four key STL elements on employees' PSY during the unprecedented COVID-19 crisis. Their research methodology involved gathering data from workers across Kenyan SMEs through a comprehensive survey instrument. Their findings revealed that STL significantly predicted PSY. When examining the hypothesized relationships, COVID-19-related anxiety emerged as a significant moderating factor in the connections between STL and PSY.

In addition, the present study indicated a significant association between STL and GIA. This result can be compared to an earlier study by Chen et al. (2025). Their investigation aimed to uncover the underlying processes and contextual factors through which STL enhanced GIA, specifically examining the intermediary function of environmental knowledge exchange. Their research collected data from subject matter experts with substantial experience in major infrastructure projects. Their analysis revealed that STL enhanced GIA. Furthermore, their study identified environmental knowledge exchange as a crucial intermediate mechanism linking STL to GIA. Their research insights provided valuable guidance for project leaders seeking to enhance environmental innovation outcomes in large-scale initiatives.

Furthermore, the current study found a significant relationship between STL and SOC. The finding is comparable to earlier research by Raza et al. (2024). Their investigation explored how STL practices influence the development of SOC both internally and externally within management groups. Their study investigated these relationships within Pakistan's construction sector. Specifically, their research analyzed the intermediary role of project team members' self-belief in their capabilities and the moderating influence of their social networks. Their research drew on data from team members working under project directors across various private-sector organizations. Their findings demonstrated that STL approaches correlate positively with project achievements and SOC. Their research findings carry significant implications for understanding leadership effectiveness in project environments, developing social capital within project teams, enhancing project success through leadership development, strengthening team members' self-efficacy, and building effective organizational networks.

Additionally, this study found that SOC and SIA were significantly associated. The result can be compared to an earlier study by Simmou et al. (2025). Their investigation examined how environmental organizational culture, SOC, and environmental knowledge exchange collectively influence SIA. Their research methodology involved comprehensive data collection from Morocco's agricultural sector. Their empirical findings demonstrated that organizational environmental culture and SOC positively influenced SIA. Their findings are relevant to developing economies where small and medium enterprises face unique challenges in implementing sustainable practices.

In addition, the current research indicates a significant relationship between SOC and PSY. The finding can be compared to a study by Liao et al. (2025). Their investigation examined the interconnections among SOC, PSY, and health-enhancing activities of senior residents in care facilities within China's Xiangxi region. Their research employed randomized cluster sampling to identify participants from eldercare facilities in Xiangxi. Their investigation gathered surveys across the participating facilities, and their mediation analysis revealed that PSY mediated SOC's overall influence on health-promoting behaviors. The findings establish psychological resources

as a significant mediating factor in the relationship between social connections and health-promoting activities. Their results suggested that interventions to improve health behaviors among elderly residents should adopt an integrated approach that addresses SOC and PSY to promote healthy aging practices effectively.

Lastly, this research indicated a significant association between PSY and SIA. The result can be compared to a study by Tang et al. (2022). Their investigation developed a theoretical framework examining the relationship between STL and SIA within green building enterprises. Their investigation pursued several interconnected objectives by examining how STL influences SIA through PSY's mediating role. Their study collected data from employees of Chinese green building enterprises via questionnaire distribution. Their analysis revealed that STL demonstrated a positive influence on PSY. Furthermore, PSY exhibited significant effects on SIA. Their findings are particularly relevant to the construction sectors of developing economies. Their understanding provides valuable insights for promoting sustainable practices in construction management.

## 5.2 Theoretical Implications

The investigation presents notable theoretical advancements to the scholarly discourse concerning STL (X. Chen et al., 2025), SOC (Simmou et al., 2025), PSY (Tho et al., 2025), and SIA (Chen, Khan, et al., 2024). Whereas prior investigations examined these elements independently, this research establishes a holistic theoretical architecture that elucidates their complex interconnections, broadening understanding of leadership's influence on organizational innovation capabilities through sociological and psychological pathways. This synthesis advances theoretical understanding from conventional linear associations toward a more sophisticated, multilayered perspective of organizational innovation dynamics.

The empirical outcomes expand the theoretical conceptualization of STL by illustrating its association with SIA via SOC and PSY mechanisms. This development extends the scholarly foundation established by Tang et al. (2022) and enhances the theoretical understanding of leadership's role in facilitating SIA through multiple channels. Additionally, the investigation extends SOC theory by empirically substantiating its mediating role between leadership practices and innovation outcomes. The findings establish SOC as a fundamental theoretical connector, explicating how leadership practices transform into concrete innovation capabilities through relational networks and resources.

PSY is included in this study as a theoretically critical mediating mechanism that resolves a fundamental tension in ambidexterity research. For instance, how individuals cognitively and emotionally manage the contradictory demands of exploitation and exploration without experiencing paralyzing role conflict. Prior research has predominantly examined structural and contextual enablers of organizational ambidexterity (Tho et al., 2025). Scholars increasingly recognize that ambidexterity ultimately depends on individual-level PSY that allows employees to engage in cognitively incompatible activities, specifically, the algorithmic thinking required for efficiency optimization versus the heuristic thinking necessary for SIA (Yan et al., 2020). PSY's four components address this cognitive paradox through distinct mechanisms, including SEF, which reduces the perceived difficulty of switching between exploitation and exploration mindsets by enhancing individuals' confidence in their behavioral flexibility (Kafeel et al., 2024). HOP provides the cognitive capacity to simultaneously hold multiple, potentially conflicting

goals (efficiency and innovation) and identify alternative pathways when one approach fails (Youssef & Luthans, 2007). OPT enables positive reframing of the inherent tensions between efficiency and innovation as complementary rather than contradictory, reducing cognitive dissonance (Lu et al., 2018). Lastly, RES allows rapid psychological recovery from the inevitable failures in exploratory innovation without abandoning commitment to exploitative efficiency standards (Musa & Enggarsyah, 2025). Empirical evidence demonstrates that individuals with higher PSY experience lower role conflict and ambiguity when performing ambidextrous tasks, exhibit superior performance in both SUSET and SUSEP activities, and maintain higher productivity levels while simultaneously engaging in creative behaviors (Tho et al., 2025). In sustainable manufacturing specifically, where employees must simultaneously maintain ISO-certified quality standards (exploitation) while experimenting with unproven green technologies (exploration), PSY serves as an individual-level resource that prevents cognitive overload and enables productive engagement in both domains. Furthermore, PSY serves as the proximal mechanism through which STL cannot directly control employees' minute-by-minute decisions to engage in efficiency versus innovation activities, but they can develop PSY that subsequently guides these micro-level behavioral choices autonomously (Njaramba, 2024). Therefore, excluding PSY would leave unexplained the individual-level psychological processes through which manufacturing employees actually execute SIA.

A significant theoretical contribution emerges in the SIA literature, demonstrating the equilibrium between SUSEP and SUSET and expanding existing theoretical frameworks that emphasize structural and organizational elements (Chen, Khan, et al., 2024). This research advances theoretical understanding beyond conventional structural approaches, suggesting that ambidextrous innovation capacity is fundamentally embedded in organizational social structures and collective psychological capabilities. These insights establish a refined theoretical framework for comprehending organizational innovation capability development in increasingly complex, sustainability-oriented environments.

### **5.3 Practical Implications**

This investigation yields significant operational insights for managers, practitioners, and policy developers seeking to strengthen innovation capabilities while preserving sustainability objectives. The empirical outcomes provide implementable strategies by demonstrating how STL approaches predict innovation through distinct SOC and PSY mechanisms.

The findings emphasize to practitioners the strategic necessity of fostering SOC and PSY as complementary innovation enablers. Organizations benefit from strategic investment in internal and external network development while concurrently strengthening the workforce's psychological attributes. This integrated strategy indicates that innovation achievement stems from both structural and psychological factors. Strategic recommendations include implementing initiatives that strengthen employee SEF, OPT, HOP, and RES while establishing network development opportunities through interdepartmental collaboration, knowledge-sharing communities, and external alliances.

For policy architects, the research underscores the importance of establishing regulatory frameworks that promote sustainable innovation while acknowledging the social and psychological dimensions of organizational capability development. Policy design should

encompass traditional innovation support mechanisms and initiatives that facilitate network formation and the development of psychological resources across organizational boundaries.

The investigation provides operational guidance for maintaining equilibrium between exploratory and exploitative innovation activities. Organizations should establish distinct support mechanisms for both innovation types, allocating dedicated resources for exploration while sustaining efficient exploitation systems. Implementation strategies should include targeted interventions to enhance PSY through professional development initiatives and structured opportunities for SOC accumulation through networking events and collaborative endeavors.

The IPMA findings necessitate a strategic recalibration of organizational resource allocation priorities. The pattern wherein PSY exhibits high performance (68.857) yet low importance (0.124) suggests that PSY operates primarily through SOC pathways rather than directly influencing SIA, implying that investments in training programs, positive work climate initiatives, employee well-being interventions will yield limited returns unless accompanied by simultaneous investments in relational infrastructure that enables psychological resources to translate into collective innovation outcomes (Nahapiet & Ghoshal, 1998). In addition, the high PSY performance indicates potential resource saturation, in which Chinese manufacturing firms' additional investments yield diminishing marginal returns. Managers should therefore maintain current PSY through existing human resource practices while redirecting incremental resources toward STL development. Furthermore, the exceptionally high importance yet low performance of STL (importance = 0.756, performance = 60.362) reveal that institutional pressures, such as China's Environmental Protection Law, Environmental Protection Tax Law, dual carbon goals, and multinational supply-chain sustainability requirements, create structural imperatives that leadership practices must navigate effectively. Consequently, organizations should prioritize leadership development initiatives that enhance managers' capabilities in articulating compelling sustainability visions that align with regulatory requirements, making trade-off decisions that balance short-term efficiency with long-term environmental performance, allocating resources toward green technology adoption despite immediate cost pressures, and building cross-functional networks that facilitate knowledge integration necessary for ambidextrous innovation.

#### **5.4 Research Limitations and Future Research Directions**

The investigation acknowledges several methodological constraints that offer avenues for subsequent research. The cross-sectional research design inherently restricts causal inference capabilities regarding the examined variables. Subsequent longitudinal investigations could establish stronger causality evidence and elucidate the temporal evolution of relationships among STL, PSY, SOC, and SIA, aligning with contemporary methodological developments in leadership research (Ho & Chan, 2022).

The research context in China's manufacturing sector potentially constrains the generalizability of results across diverse cultural environments and industrial domains. Further validation studies across varied cultural contexts and industrial sectors warrant attention, particularly in service-oriented domains where innovation dynamics manifest differently.

While the investigation examined SOC and PSY as mediating mechanisms, additional mediating and moderating factors may predict these relationships. Subsequent research could examine the role of organizational culture and environmental uncertainty as mediating variables. Scholars

might also investigate how alternative approaches beyond STL interact with SOC and PSY to shape innovation outcomes.

Although this research examined SIA as an integrated construct, future investigations could independently analyze the differential effects of leadership and capital forms on exploratory versus exploitative innovation. This approach could yield refined insights into how organizations manage these competing demands.

A significant methodological limitation concerns the nested structure of the collected data and the absence of firm-level identifiers. Employees within the same organization may exhibit correlated responses due to shared organizational culture, leadership practices, or environmental conditions—a phenomenon quantified through intraclass correlation coefficients (ICC). The current analysis does not account for such clustering effects, as firm identifiers were not retained to protect participant confidentiality (Hox et al., 2017). Future studies could calculate and report ICCs for key study variables to quantify firm-level clustering and inform appropriate analytical strategies. In addition, cross-classified multilevel models could be explored to account for multiple clustering sources (e.g., employees nested within both firms and industry sectors). These methodological refinements would strengthen causal inference and enhance the generalizability of findings regarding the relationships among STL, SOC, PSY, and SIA.

### **Conflict of Interest**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

### **Author Contributions**

YT: Conceptualization, Methodology, Formal Analysis, Writing – original draft, Writing – review & editing; LH: Conceptualization, Methodology, Formal Analysis, Writing – original draft, Writing – review & editing; LZ: Conceptualization, Methodology, Formal Analysis, Writing – original draft, Writing – review & editing.

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### **Data Availability Statement**

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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### **Ethical approval statement**

Committee: School of Marxism, Chengdu Medical College

Approval Number: CMC250321003

Date: March 21, 2025

This document mainly describes the research topic of Yaun Tang, Lingling Huang, and Li Zou, entitled "An understanding of sustainable transformational leadership and sustainable innovation ambidexterity: the mediating roles of social and psychological capital." It is not for minors, pregnant women, people with physical or mental disabilities, or people with spiritual disabilities.

In addition, the following description of this research case is exempt from the ethics review committee review due to one of the following circumstances: 1. There is no invasive method for collecting the required data in this study. 2. This study adhered to ethical guidelines and principles, ensuring the protection of participants' rights and confidentiality throughout the research process. 3. The written consent form provided detailed information about the study's objectives, procedures, potential risks, and participants' rights, allowing them to make an informed decision about their participation.

### Statement of Informed Consent

This study was conducted in accordance with established ethical guidelines, ensuring that all participants provided voluntary and written informed consent prior to their involvement (April 2025 to May 2025).

The objectives, methodology, and confidentiality measures were clearly communicated, emphasizing that participation was entirely voluntary and that respondents retained the right to withdraw at any stage without consequence. To safeguard participant privacy, all responses were anonymized, with no personally identifiable information collected or disclosed.

The study adhered to the ethical standards and institutional policies governing research involving human subjects. By completing the survey, participants confirmed their understanding and agreement with the study's terms, including the assurance of confidentiality and the exclusive use of data for academic purposes. The researchers remain committed to maintaining the highest standards of integrity, transparency, and ethical responsibility in the handling and reporting of research data.

### TABLES

Table 1. Convergent Validity

Constructs	Indicators	VIF	Factor Loadings	Cronbach's alpha	Rho_A	Rho_C	AVE
HOP	HOP1	1.348	0.626	0.770	0.775	0.840	0.684
	HOP2	1.919	0.631				
	HOP3	1.542	0.745				
	HOP4	1.756	0.717				
	HOP5	1.355	0.620				
	HOP6	1.637	0.751				
OPT	OPT1	1.402	0.678	0.729	0.752	0.816	0.658

	OPT2	1.592	0.743				
	OPT3	1.502	0.723				
	OPT4	1.327	0.662				
	OPT5	1.361	0.685				
RES	RES1	1.427	0.652	0.789	0.794	0.851	0.700
	RES2	1.291	0.596				
	RES3	1.714	0.758				
	RES4	1.671	0.746				
	RES5	1.462	0.703				
	RES6	1.591	0.730				
SEF	SEF1	1.445	0.663	0.778	0.781	0.844	0.689
	SEF2	1.353	0.702				
	SEF3	1.468	0.720				
	SEF4	1.476	0.734				
	SEF5	1.544	0.617				
	SEF6	1.327	0.693				
SOC	SOC1	1.433	0.750	0.742	0.748	0.837	0.751
	SOC2	1.442	0.748				
	SOC3	1.465	0.789				
	SOC4	1.357	0.713				
STL	STL1	1.617	0.722	0.861	0.863	0.896	0.768
	STL2	2.139	0.818				
	STL3	1.910	0.788				
	STL4	1.897	0.783				

	STL5	1.629	0.731				
	STL6	1.784	0.764				
SUSEP	SUSEP1	1.592	0.700	0.858	0.860	0.894	0.765
	SUSEP2	2.035	0.789				
	SUSEP3	2.012	0.790				
	SUSEP4	1.718	0.752				
	SUSEP5	2.043	0.803				
	SUSEP6	1.901	0.753				
SUSET	SUSET1	1.672	0.742	0.841	0.845	0.888	0.783
	SUSET2	2.637	0.875				
	SUSET3	1.724	0.779				
	SUSET4	1.553	0.730				
	SUSET5	1.957	0.782				

Note: HOP = Hope, OPT = Optimism, RES = Resilience, SEF = Self-efficacy, SOC = Social Capital, STL = Sustainable Transformational Leadership, SUSEP = Sustainable Exploratory Innovation, SUSET = Sustainable Exploitative Innovation.

Table 2. Fornell and Larcker Criterion

Constructs	HOP	OPT	RES	SEF	SOC	STL	SUSEP	SUSET
HOP	<b>0.827</b>							
OPT	0.730	<b>0.811</b>						
RES	0.754	0.711	<b>0.836</b>					
SEF	0.678	0.689	0.686	<b>0.830</b>				

SOC	0.529	0.583	0.549	0.513	<b>0.866</b>			
STL	0.529	0.521	0.588	0.529	0.676	<b>0.876</b>		
SUSEP	0.549	0.573	0.592	0.577	0.763	0.762	<b>0.874</b>	
SUSET	0.402	0.472	0.450	0.458	0.617	0.666	0.804	<b>0.884</b>

Note: HOP = Hope, OPT = Optimism, RES = Resilience, SEF = Self-efficacy, SOC = Social Capital, STL = Sustainable Transformational Leadership, SUSEP = Sustainable Exploratory Innovation, SUSET = Sustainable Exploitative Innovation.

Table 3. Heterotrait-monotrait ratio (HTMT)

Constructs	HOP	OPT	RES	SEF	SOC	STL	SUSEP	SUSET
HOP								
OPT	0.856							
RES	0.868	0.839						
SEF	0.870	0.892	0.871					
SOC	0.685	0.772	0.708	0.669				
STL	0.645	0.666	0.713	0.644	0.839			
SUSEP	0.672	0.714	0.718	0.705	0.856	0.883		
SUSET	0.499	0.603	0.555	0.567	0.784	0.784	0.846	

Note: HOP = Hope, OPT = Optimism, RES = Resilience, SEF = Self-efficacy, SOC = Social Capital, STL = Sustainable Transformational Leadership, SUSEP = Sustainable Exploratory Innovation, SUSET = Sustainable Exploitative Innovation.

Table 4. Correlations

Relationships	Path Coefficient ( $\beta$ )	Lower CI	Upper CI
SOC -> HOP	0.329	0.232	0.423
SOC -> OPT	0.324	0.226	0.417
SOC -> PSY	0.368	0.259	0.472
SOC -> RES	0.331	0.233	0.424
SOC -> SEF	0.317	0.224	0.408
SOC -> SUSEP	0.392	0.307	0.477
SOC -> SUSET	0.384	0.301	0.468
STL -> HOP	0.551	0.481	0.618
STL -> OPT	0.543	0.471	0.611
STL -> RES	0.553	0.484	0.618
STL -> SEF	0.531	0.461	0.597
STL -> SOC	0.677	0.610	0.738
STL -> SUSEP	0.726	0.675	0.770
STL -> SUSET	0.711	0.661	0.755

Note: HOP = Hope, OPT = Optimism, RES = Resilience, SEF = Self-efficacy, SOC = Social Capital, STL = Sustainable Transformational Leadership, SUSEP = Sustainable Exploratory Innovation, SUSET = Sustainable Exploitative Innovation.

Table 5. Hypotheses Results

Hypotheses	Path Coefficient ( $\beta$ )	T values	P values
H1: STL -> PSY	0.367	6.863	0.000
H2: STL -> SIA	0.433	9.057	0.000
H3: STL -> SOC	0.677	20.734	0.000
H4: SOC -> PSY	0.368	6.817	0.000
H5: SOC -> SIA	0.362	7.975	0.000
H6: PSY -> SIA	0.126	2.694	0.007

Note: PSY = Psychological Capital, SOC = Social Capital, STL = Sustainable Transformational Leadership, SIA = Sustainable Innovation Ambidexterity.

Table 6. Indirect Relationships

Hypotheses	Path Coefficient ( $\beta$ )	T values	P values
STL -> SOC -> PSY	0.249	6.597	0.000
STL -> SOC -> SIA	0.245	7.217	0.000
SOC -> PSY -> SIA	0.047	2.401	0.016
STL -> PSY -> SIA	0.046	2.410	0.016
STL -> SOC -> PSY -> SIA	0.032	2.374	0.018

Note: PSY = Psychological Capital, SOC = Social Capital, STL = Sustainable Transformational Leadership, SIA = Sustainable Innovation Ambidexterity.

Table 7. Predictive Accuracy and Effect Size Assessment

Endogenous Constructs	R <sup>2</sup>	R <sup>2</sup> Adjusted	Q <sup>2</sup>	Q <sup>2</sup> Predict	Predictors	f <sup>2</sup>
PSY	0.452	0.450	0.300	0.373	STL	0.133
					SOC	0.134
SIA	0.671	0.669	0.450	0.571	STL	0.275
					SOC	0.192
					PSY	0.026
SOC	0.458	0.456	0.276	0.455	STL	0.843

Note: PSY = Psychological Capital, SOC = Social Capital, STL = Sustainable Transformational Leadership, SIA = Sustainable Innovation Ambidexterity.

Table 8. IPMA results

Construct	Importance	Importance Ranking	Performance	Performance Ranking
STL	0.756	1	60.362	3
SOC	0.409	2	63.059	2
PSY	0.124	3	68.857	1

Note: PSY = Psychological Capital, SOC = Social Capital, STL = Sustainable Transformational Leadership.

## Figure Legends

### Figure 1

Title: **Figure 1.** Research Framework

Description: Figure 1 indicates the theoretical framework based on the constructs and their proposed relationships.

**Figure 2**

Title: **Figure 2.** Research Results

**Note:** \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

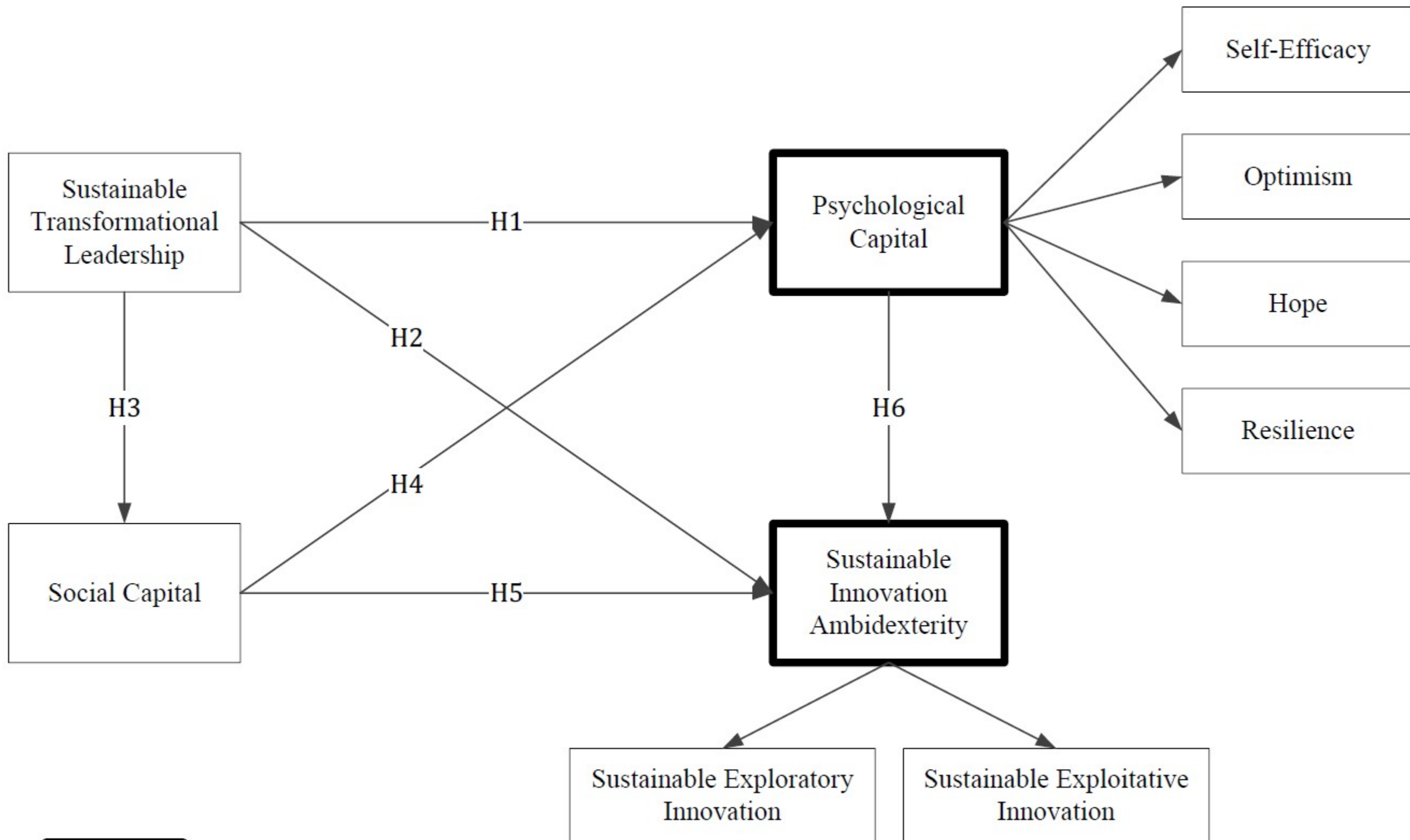
Description: Figure 2 indicates the empirical results of the proposed hypotheses.

**Figure 3**

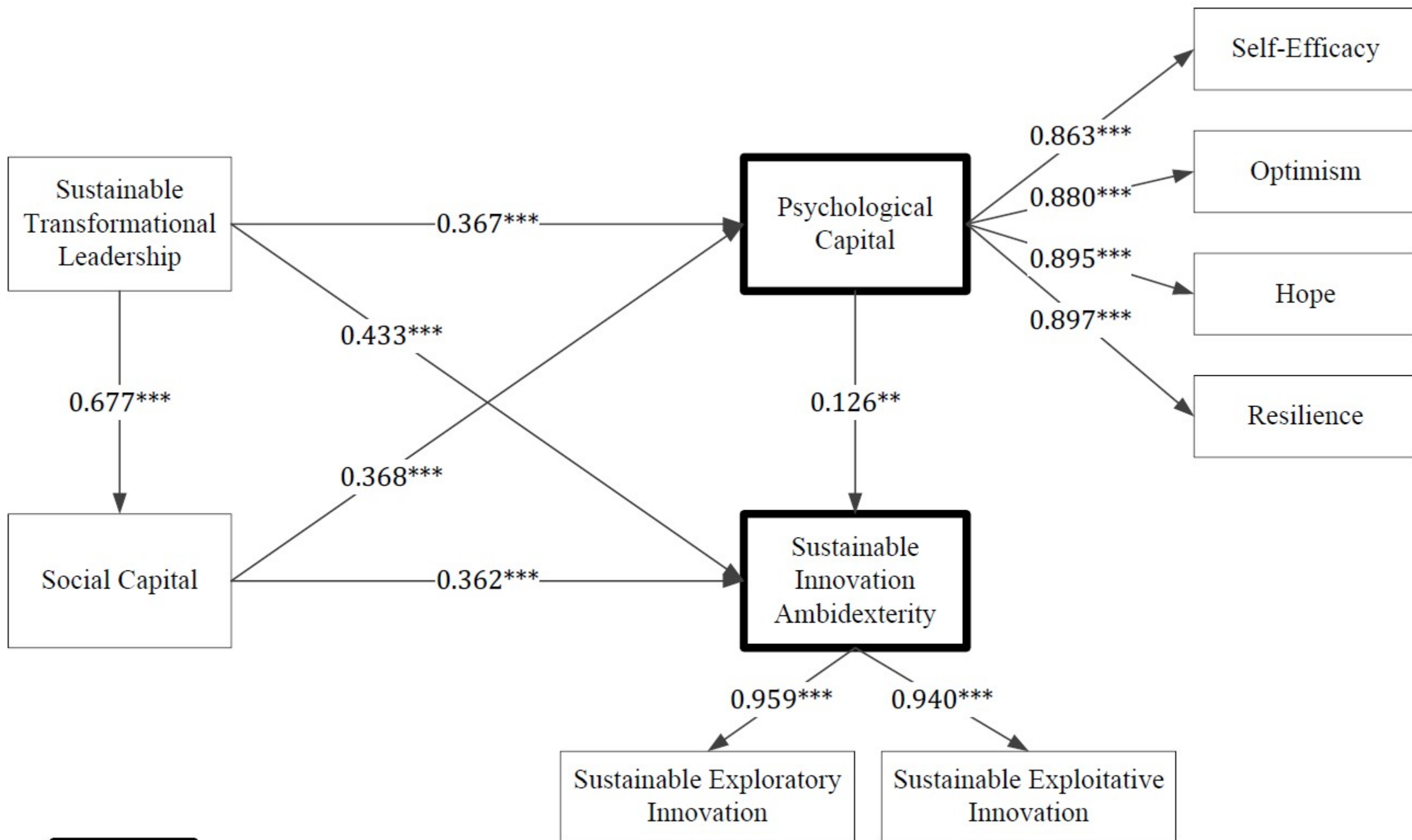
Title: **Figure 3.** IPMA

Description: Figure 3 plots an importance-performance map analysis of all the predecessor constructs relative to sustainable innovation ambidexterity.

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Note: Second-order reflective construct



Note: Second-order reflective construct

## Importance-performance map

