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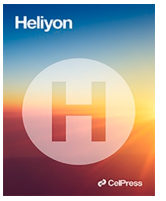

Research article

Corporate sustainable development performance through top management team's transactive memory system and organizational resilience: A moderated mediation analysis

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ABSTRACT

Addressing the measurement of corporate sustainable development performance (SDP) in economic, social, and environmental dimensions is a pressing global challenge. This study investigates the intrinsic impact mechanisms of the top management team's transactive memory system (TMT TMS) on SDP within Chinese manufacturing firms. It extends the analysis by introducing opportunity alertness (OA) as a moderating variable and organizational resilience (OR) as a mediating variable. Notably, OA was found to have a moderating mediation effect on the TMT TMS-OR-SDP pathway. Data from 294 executives was collected through non-probability convenience sampling. Initially, exploratory factor analysis was conducted utilizing SPSS; confirmatory factor analysis was performed with the aid of AMOS. Additionally, hierarchical regression and the SPSS PROCESS macro were employed to test the hypothesized models and paths of influence. The results illuminate the positive impact of TMT TMS on SDP through the enhancement of OR, a relationship further strengthened by OA. This study adds to the theoretical understanding and offers practical insights for optimizing TMT TMS and OA to achieve corporate sustainable development.

1. Introduction

Sustainable development, a term first defined in the Brundtland Report of 1987, has become an essential agenda item for many global businesses and institutions [1–5]. Sustainable development involves a complex balance of economic, social, and environmental aspects, often referred to as the "triple bottom line," forming the basis of corporate sustainable development performance (SDP) [6]. The concept goes beyond the traditional profit-oriented focus of organizations, emphasizing the need for effective management, monitoring, and integration of environmental, social, and broader economic impacts. In the modern volatile, uncertain, complex, and ambiguous business environment, this multidimensional performance is crucial for organizational success and sustainable development [7].

As a leading emerging market on the global stage, China grapples with the challenge of balancing rapid economic growth with

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sustainable development. This balancing act is particularly noticeable in the manufacturing sector, which serves as a linchpin in the economy and supply chain, especially against the backdrop of the "Dual Carbon" policy and growing consumer scrutiny over corporate social responsibility [8,9]. Owing to increasing competition in global manufacturing, the Chinese industry faces considerable internal and external pressures, including those related to sustainability [10,11]. In the context of sustainability-related challenges, the influence of an organization's senior leadership team is particularly noteworthy. The upper echelon collaboratively sets the strategic course of the enterprise [12]. Their purview encompasses momentous choices such as the distribution of resources, institutional governance, strategic synchronization, and operational execution [13,14]. As a resource-intensive and technology-dependent industry, manufacturing is not only an engine for economic growth but also a key consideration in environmental and social responsibilities. Given China's robust infrastructure in manufacturing, the industry possesses unique advantages for empirical research and offers further opportunities to explore existing theories, such as resource-based views and dynamic capabilities within a contemporary context. Consequently, investigating how Chinese manufacturing enterprises optimize SDP through management and operations holds significant implications.

Achieving sustainable development requires businesses to balance and succeed on the economic, social, and environmental dimensions [15]. However, due to the complexity and interrelationships of these three dimensions, it is a challenging task [4]. Najib et al. [16] empirically investigated the positive influence of employee innovation potential, organizational innovation culture, and innovation on the sustainable development of SMEs from the perspective of sustainable innovation. Furthermore, there have been studies exploring sustainability factors and drivers from different angles, including green absorptive capacity, sustainable human capital, and organizational support [17]; quality management practices [15]; proactive sustainability strategies and sustainability control systems [18]; and green human resource management and dynamic, sustainable capabilities [19]. However, the mechanisms driving successful SDP, particularly from an internal organizational perspective, have yet to be thoroughly explored [20].

While extensive academic literature has been dedicated to the study of SDP, there remains a gap in understanding the specific mechanisms driving its success, particularly from the internal organizational perspectives of managerial or corporate-level attributes [20–22]. In various studies, the role of the TMT has been significantly associated with organizational performance and strategy [23–25]. However, the nexus between these two constructs, especially the specific role of TMT's Transactive Memory Systems (TMT TMS) in influencing SDP, remains theoretically and empirically underexplored. Building on this gap, it is worth noting that recent work by Kim [26] on the distinct roles of TMTs and boards in shaping a firm's absorptive capacity offers a steppingstone to our study. Kim's [26] investigation suggests that TMTs and boards act as collective gatekeepers in the knowledge management process, each playing a specific role in different stages of absorbing, assimilating, and exploiting external knowledge. While this research does not directly examine the role of TMT TMS in SDP, it highlights the complexity and specialization of functions within the TMT in the broader context of organizational knowledge and performance. That implies that a nuanced understanding of mechanisms such as TMT TMS could be crucial in influencing generic organizational performance and sustainability-specific outcomes like SDP.

This study makes substantial theoretical and managerial contributions in the context of China's manufacturing industry by addressing frameworks of the resource-based view (RBV) and dynamic capabilities view (DCV). TMS is indispensable for enhancing the efficiency of TMT, as it provides a platform for the executive team to cultivate, disseminate, and unify knowledge based on the diverse expertise of its members. That improves the team's capabilities in distinguishing and coordinating strategic agendas [27]. Within a team, each individual possesses a "mental map" regarding distributing specific knowledge or skills among people or departments. These mental maps aggregate to form a more extensive, organization-level memory and knowledge management system, commonly called organizational TMS [28]. In this sense, TMS essentially evolves as a shared "mental map" developed by the team, designated to specify its members' professional knowledge and responsibilities.

By introducing TMT TMS as an organically evolving unique asset and a critical intangible resource, the study serves as a bridge between RBV and DCV, yielding new insights. It also elucidates the mediating role of organizational resilience (OR) and the moderating role of opportunity alertness (OA) in the relationship between TMT TMS and SDP, adding contextual and dynamic dimensions to the traditional 'resource-capability-performance' framework. DVC provides a lens through which to understand how executives' OA moderates the relationship between TMT TMS and OR, allowing for the dynamic reallocation of internal resources to achieve superior sustainable development outcomes [29]. Managerially, this research is particularly pertinent to manufacturing enterprises in China. It underscores the necessity of strategic alignment between knowledge management systems and organizational goals and offers practical strategies like holding regular team meetings and cross-functional working groups for effective knowledge dissemination and collaborative learning.

The structure of this paper comprises several vital sections. The second section provides a literature review on SDP, TMT TMS, OR, and OA and further proposes research hypotheses. The third section elaborates on the data collection information and methodology employed in the study. The fourth section presents the main findings and associated discussions. The paper's concluding section summarizes the research outcomes, discusses their implications for academia and managerial practice, and identifies the current study's limitations, along with suggestions for future research.

2. Literature review and hypothesis development

2.1. TMT TMS and SDP

The TMS is a collective memory system that combines individual and group memories, describing how team members effectively utilize each other's memories to store, retrieve, and communicate information across different knowledge domains [30,31]. Group members' memories can serve as valuable resources for each other, enabling them to access information through other members'

memories, thereby eliminating the need for individual learning and memorization. Accordingly, the TMT TMS is a system where TMT members recognize and share their expertise stored in personal and collective memories through repeated coordination and interaction [32]. Current research on TMS has primarily focused on general team activities, with limited studies specifically addressing TMS within TMTs. Awwada et al. [33] noted that in practice, the TMT's collective cognition, resources, and efforts, rather than individual executives, significantly impact strategic decision-making in organizations, and TMTs' rich collective cognition can be effectively measured through TMS.

As a division of labor mechanism [31,34], TMT TMS assists top executives in identifying more competitive cues in environmental scanning and strategic decision-making [35], thereby reducing their cognitive burden via sharing. This mechanism enables executive members to focus better on resource organization and utilization, enhancing their insight and responsiveness to potential risks and ultimately improving company performance. Firstly, TMT TMS aids in expanding the knowledge of executive members, reducing the time and effort required to absorb necessary knowledge, thereby enhancing company performance [32]. Secondly, TMT TMS allows members to have diverse interpretations and perspectives on the competitive environment, creatively addressing various competitive situations by linking their professional knowledge and interpretations of environmental issues [35].

Moreover, a well-developed TMT TMS reduces the narrow perceptual range of the team, enabling more comprehensive, holistic, and high-quality strategic decision-making by effectively collecting and utilizing information from team members and external sources [32]. Thus, an efficient TMT TMS represents the effective integration of expertise within the executive team, enabling members to acquire not only specialized knowledge within the team but also a better understanding of the team's management dynamics [27,36].

It is precisely this integrated and comprehensive decision-making capability that enables organizations better to adjust their strategies and operations following sustainability principles. Since a firm's sustainability is not just a slogan but a robust framework embedded in its strategies and operating practices, it operationalizes the relationships with stakeholders and the impacts on the natural environment. This integrated approach requires a multi-disciplinary perspective, incorporating environmental stewardship, social responsibility, and financial viability as interconnected facets of a cohesive sustainability strategy [37]. Therefore, with its rich collective cognition and diverse expertise, a well-functioning TMT TMS is particularly well-suited for integrating these disparate elements and accomplishing this complex task [30,38]. It provides a mechanism through which the TMT can better assess the trade-offs and synergies between different sustainability objectives, thus positively impacting sustainability programs. Moreover, the professional coordination facilitated by TMT TMS allows managers to incorporate economic, social, and environmental factors into the organization's operations and vision.

The RBV explains how firms leverage unique resources and capabilities to gain competitive advantages. Based on RBV, we argue that an effective TMT TMS is a unique organizational resource, providing information and knowledge and the capability to utilize these resources effectively towards sustainability objectives. The specific knowledge residing within all members serves as the foundation of the firm's capabilities and is a valuable, non-imitable resource [39]. A high level of intensity in TMT TMS requires a clear understanding and trust among members regarding each other's expertise, information, and the coordination level achieved in pursuing organizational objectives [40]. The specific knowledge residing within the TMT and facilitated through TMS can be fully leveraged to incorporate sustainability goals into organizational strategy, making it a valuable, rare, and non-imitable resource, contributing to enhancing SDP. Therefore, the ability of TMTs to effectively share and coordinate knowledge through TMS should be directly related to the quality and efficacy of sustainability-related decisions and measures, thereby affecting the firm's sustainability programs. So.

Hypothesis 1 (H1). TMT TMS has a positive effect on firm's SDP.

2.2. The mediating role of organizational resilience

SDP has become a pivotal objective in corporate strategic management and is this study's primary variable under investigation, which encompasses three core dimensions: environmental, social, and economic performance. Given this multidimensional framework, organizations need robust internal resources and capabilities and dynamic adaptability. In this context, OR is posited to play a vital role.

The concept of resilience has been applied across various disciplines, from psychology and ecology to organizational management and strategy. Woods [41] argued that resilience is an organization's ability to cope with change and disruption within predefined adaptive mechanisms but a broader capacity to manage variations outside these predefined models. In management studies, OR is defined as the organization's ability to swiftly recover from competitive crises and disasters through reallocation of internal resources, optimizing organizational processes, reshaping relationships, and leveraging crises for countercyclical growth [42]. Literature indicates that fostering OR can create new opportunities in adversity [43], confer competitive advantages [2,44], and improve market performance [45].

RBV posits that an organization's unique internal resources are crucial to achieving sustainable competitive advantage [46]. In a manufacturing context, OR acts as a unique, difficult-to-imitate, and non-substitutable resource [47], harboring potential value. When facing environmental or social stress, OR enables more efficient resource allocation and usage [48,49], contributing to improved performance across environmental, social, and economic dimensions. In manufacturing, such anticipatory capabilities can be manifested through more efficient supply chain management, faster market response, and more precise strategic planning.

DCV emphasizes the need for organizations to dynamically adjust and reconfigure resources and capabilities in response to evolving environments [29]. This perspective aligns closely with that of Hamel and Valikangus [50], who view OR as an active and proactive form of dynamic capability. They argue that it involves survival and recovery under duress and the ability to adjust business models and strategies dynamically to mitigate adverse effects on core organizational competencies.

Consequently, this study argues that OR possesses the potential to positively influence performance across all dimensions of SDP in the manufacturing sector by forecasting, adapting, and transforming opportunities. This claim is robustly supported by both resource-based and dynamic capability theories, which underscore the impact of internal resources and dynamic adaptability on organizational performance. Therefore, OR should be considered a key strategic resource and capability in the quest for SDP within manufacturing enterprises. So.

Hypothesis 2 (H2). TMT TMS has a positive effect on organizational resilience.

In the context of RBV and DCV, resources and capabilities are pivotal for firms to acquire and sustain competitive advantages [29,46]. As previously discussed, organizations striving for sustainable development require excellent performance across multiple dimensions. That necessitates strategic orientation, innate flexibility, and adaptability, termed OR. Based on the "resource-capability-performance" framework, this research posits that the TMT TMS can be viewed as a strategic resource that fosters knowledge sharing, decision-making efficiency, and organizational learning. Meanwhile, OR is considered a dynamic capability enabling firms to reconfigure and integrate resources in a constantly changing environment to achieve SDP.

Firstly, TMT TMS acts as a system for storing and retrieving information and knowledge, enhancing collaboration and coordination among team members. This is primarily because TMT TMS helps delineate the expertise and responsibilities of each team member, thereby reducing risks of information redundancy and mishandling [32,51]. Effective knowledge management allows firms to adapt to market changes and withstand competitive pressures swiftly. As per RBV, organizational resources and capabilities are the fount of competitive advantage. As one of the core organizational resources, TMT plays an essential role in information processing and decision-making. Literature reveals that an effective TMT TMS can broaden, deepen, and expedite decision-making through team members' specialized knowledge and integrated advantages [32].

Secondly, DCV further emphasizes that organizations need capabilities to adapt, integrate, and reconfigure internal and external resources in a continually evolving environment. In this aspect, TMT TMS not only aids in efficient knowledge acquisition and insights but also enhances the TMT's "interpretive repertoire" [32](p. 3), which in turn fosters OR. OR serves as a unique "dynamic capability" allowing firms to reconfigure their resources and capabilities amidst uncertainty [43](p. 252), and aids organizations in recovering and adapting to various crises and challenges, thereby preserving its core capabilities and values [51]. OR not only optimizes the functioning of TMT TMS but also enables firms to address the multi-dimensional challenges of sustainable development more effectively.

Moreover, from the perspective of SDP, economic, social, and environmental performances are interlinked. In this context OR becomes critical by enhancing investment in diversity or applying "multiple ideas" [49,52,53]. Diversity or multiple ideas — whether viewed through the lenses of TMT member backgrounds, cultures, professional skills, or through the diversification of organizational products, services, and markets — enhances OR to external shocks and resilience. Multiple ideas further enrich this capability by fostering the fusion of diverse perspectives and methodologies, enhancing the organization's innovative ability and flexibility in solving complex problems.

Therefore, in the relationship between TMT TMS and SDP, OR connects, mediates, and catalyzes the effects of TMT TMS on SDP. That is, through OR, the impacts of TMT TMS are translated and amplified across a broader performance spectrum. This mediating effect is especially crucial in the context of Chinese manufacturing firms, given the complex challenges they face in supply chain issues, environmental sustainability, and market competition. High OR and effective TMT decision-making mechanisms (TMT TMS) become keys to enhancing SDP. Therefore.

Hypothesis 3 (H3). Organizational resilience mediates the relationship between TMT TMS and corporate SDP.

2.3. The moderating role of opportunity alertness

Alertness was initially proposed by Kirzner [54] and refers to the ability to be more consciously aware of changes, opportunities, and overlooked possibilities. It is a cognitive characteristic demonstrated in human decision-making processes. Alertness has been widely studied in entrepreneurship research, with Tang et al. [55] considering it as the ability of entrepreneurs to accumulate, transform, and select information related to entrepreneurial opportunities. Subsequently, Tang et al. [56] emphasized the focus on information, stating that alertness refers to the entrepreneur's ability to scan and search for new information, connect the pieces of information, and assess whether the new information can develop into a good opportunity. Neneh [57] pointed out that alertness, as a fundamental element in entrepreneurship, aids in opportunity identification. According to Yang and Yang [58], the one with alertness capability could recognize gaps in the current market and envision or speculate on potential market opportunities. Alertness is also a cognitive ability that integrates the processing of prior knowledge and experience, information handling, pattern recognition of environmental potential, and engagement in social interactions [59,60]. Montiel-Campos [60] noted that alertness can be used not only to understand the opportunity identification process but also to explore its impact on organizational functioning. Based on this, the study argues that OA describes the ability of managers to identify potential opportunities and take action in environment.

Based on the prior argument, we have understood that TMT TMS can be viewed as a unique and difficult-to-imitate cognitive resource, affecting how an organization effectively responds to changes and challenges, further influencing OR and SDP. However, according to DCV, this study posits that introducing OA as a variable that allows companies to perceive and seize opportunities and reconfigure their resource base to adapt to environmental changes is meaningful. In such a context, OA not only enhances the role of TMT TMS but also further improves OR. As a valuable organizational resource, this resilience leads to better SDP.

Specifically, OA is defined as executives' ability to accurately identify new market opportunity signals, acquire the latest information and trends (including the latest resources and technology), and the likelihood of timely creating and providing new value for customers [60]. A TMT with high OA can rapidly capture and transmit the latest market opportunity signals [61], thereby

strengthening TMT TMS and laying the foundation for a new round of system joint operations. This recognition is not limited to passively capturing external signals but includes in-depth analysis and interpretation of these signals to discern their potential value and business applications. That is consistent with DCV, which emphasizes that companies need stable resources and capabilities and the dynamic capability to flexibly configure these resources and capabilities to adapt to a changing environment [29]. Therefore, OA enables the TMTs to be more proactive and accurate in gathering information and making decisions, reducing information asymmetry and the lag in decision-making.

Secondly, the high alertness of TMT members means they can search for, connect, and evaluate new information [62]. High OAenables them to perceive the competitive situation keenly, integrate various information connections, accurately assess competitive risks, and formulate creative coping strategies, thus providing strong support for the team and the organization to withstand competitive risks and meet challenges [60,63]. Simultaneously, by facilitating the full flow of information and deep integration of knowledge, OA enhances the TMT TMS's synergistic effect. That is consistent with the RBV, which states that a firm's competitive advantage comes from its unique, scarce, irreplaceable, and difficult-to-imitate resources and capabilities.

Furthermore, in a dynamic market environment, highly alert managers do not accept new information as a given fact [56]. An effective TMT TMS provides members with a collaborative platform to identify new information and resources, allowing team members to question each other, conduct joint research, and assess the potential of new information and resources. In this way, OA, as a dynamic capability, interacts with the internal cognitive resources of TMT TMS, promoting enhanced OR and SDP. Building upon this discussion, the study hypothesizes the following relationship, which is visually depicted in Fig. 1.

Hypothesis 4. **(H4)** Opportunity alertness moderates the relationship between TMT TMS and organizational resilience such that relationship is strengthened (weakened) as alertness increases (decreases).

Hypothesis 4a. **(H4a)** The positive indirect effect of TMT TMS on corporate SDP via organizational resilience is moderated by opportunity alertness such that the indirect effect is strengthened (weakened) as alertness increases (decreases).

3. Research methodology

3.1. Sample and data collection

To test our research hypotheses, we used a convenience sampling technique and conducted a questionnaire survey with manufacturing companies in China. China's position as a leading emerging market has garnered widespread attention in the academic community. According to data compiled from the *China Statistical Yearbook*, the number of industrial SMEs in China was 369,337 in 2018. This figure slightly increased to 369,605 in 2019, then jumped to 391,355 in 2020, and expanded to 433,027 in 2021. By 2022, the number had reached 463,897. This progressive increase accurately reflects the continual growth of China's SMEs in industry, with a total growth rate of 25.6 % from 2018 to 2022. Concurrently, the share of total industrial profits attributable to SMEs is also noteworthy. This share was 51.6 % in 2018, increased to 55.1 % in 2019, and rose to 57.5 % in 2020. To ensure the relevance and applicability of the research and to generalize the study findings to similar settings, this study has thus chosen China's SMEs as its research context [64].

The data collection for this study took place from July to November 2022, primarily focusing on regions such as Hebei province. Given that the questionnaire covers multiple facets of corporate operations and involves queries pertinent to the top management teams, it was deemed appropriate to target mid-level and senior management personnel for data collection. Two methods for distributing the questionnaire and collecting data were in-person responses from MBA students and commissioned surveys.

For the in-person channel, questionnaires were administered to MBA students in universities in Hebei province. These students

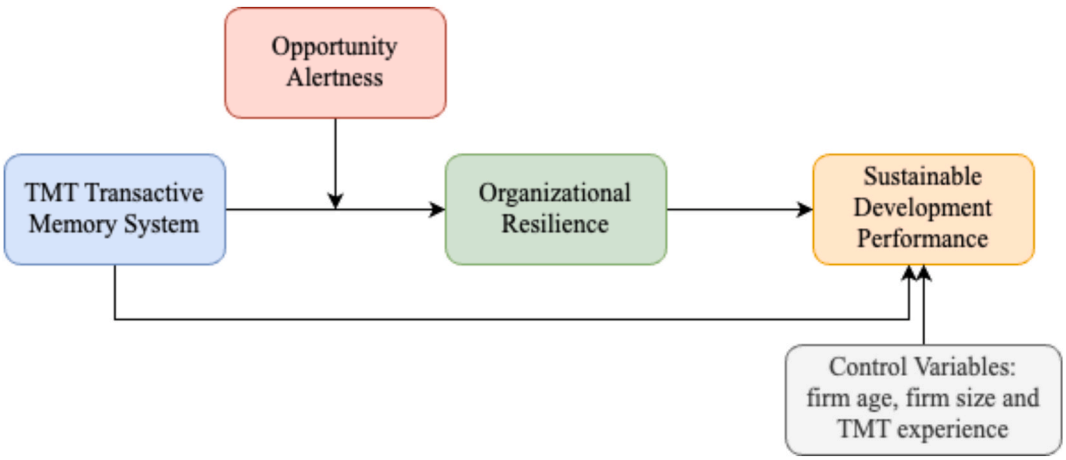

Fig. 1. Research model.

have either previously held or are currently holding mid-to-senior management roles in relevant enterprises. 42 questionnaires were distributed in this manner, with 30 responses collected. The commissioned channel consisted of a professional survey company administering the questionnaire in China, which resulted in 312 collected responses. Overall, a total of 342 questionnaires were gathered. After excluding 48 invalid responses with either missing key variables or clear patterns of random answers, the final sample size amounted to 294 valid responses. That represents an effective response rate of 86 %. We believe that a final sample size of 294 valid responses is appropriate for this study, as it meets the general statistical power requirements and aligns with the empirical rule of "an ideal sample size-to-parameters ratio would be 20:1" [65](p.12).

Upon determining the sample size, data analysis revealed that 38.4 % of the respondents were female and 61.6 % were male executives. Regarding their tenure in the company, 47.6 % had worked for 1–5 years, 36.7 % for 6–10 years, and 15.5 % for over ten years. Regarding their tenure in the TMT, 79.1 % had served for 1–5 years, 19.6 % for 6–10 years, and 0.9 % for over ten years. As for TMT size, 61.5 % consisted of 3–8 members, while 25 % had 12 or more members.

3.2. Variable measurement

This study aims to explore the relationship between TMT TMS and OR, OA, and SDP through the construction of a survey questionnaire. The questionnaire comprises background information and four scales, namely TMT TMS, OR, OA, and corporate SDP (including economic, social, and environmental performance), measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). And the Chinese translation of our questionnaire was reviewed and modified by two English professors with expertise in the field to ensure the accuracy and consistency of language expression.

The scale used to assess TMT TMS is derived from Lewis's [66] work, encompassing three dimensions: specialization, credibility, and coordination. In order to emphasize the team members' interactive memory, we modified the subject of the questions to "our team members." An eight-item scale was conducted to measure OR drawn by Kantur and Say [67]. The variable of OA is based on the research conducted by Roundy et al. [68]. We developed a scale comprising five measurement items to assess this construct in line with their study. Meanwhile, following Paulraj [69] and Wang et al. [70], corporate SDP is designed as a second-order hierarchical construct in this study, with three first-order levels of control: economic performance (ECP) which was measured using three items; social performance (SOP) and environmental performance (ENP) which were measured by a four-item scale, respectively [1,71]. Table 1 presents measurements in detail.

Table 1
Measurement model results.

Construct	Construct measurement	Factor loading (CFA)
TMT TMS ($\alpha = 0.880, CR = 0.881,$ $AVE = 0.599$)	TTS1. Team members have specialized knowledge in certain task aspects.	0.873
	TTS2. Team members trust the credibility of each other's project knowledge.	0.791
	TTS3. Team members rely on each other's information during discussions.	0.744
	TTS4. Team members work together in a well-coordinated fashion.	0.701
	TTS5. Team members possess task-related problem-solving capabilities.	0.750
Organizational resilience ($\alpha = 0.940, CR = 0.940,$ $AVE = 0.663$)	OR1. Emphasis on organization's stability and preservation.	0.828
	OR2. Emphasis on organization's diverse solution generation.	0.775
	OR3. Emphasis on organization's unwavering resilience.	0.831
	OR4. Emphasis on organization's relentless pursuit.	0.804
	OR5. Emphasis on rapid action.	0.823
	OR6. Emphasis on organizational agility in action.	0.802
	OR7. Emphasis on employee engagement and fulfillment.	0.845
	OR8. Emphasis on cohesive teamwork.	0.803
Opportunity alertness ($\alpha = 0.932, CR = 0.932,$ $AVE = 0.733$)	OA1. I perceive unique business opportunities.	0.889
	OA2. My competitive market instincts are reliable.	0.831
	OA3. I'm adept at spotting positive changes in my business environment.	0.864
	OA4. I anticipate market trends.	0.851
	OA5. I excel in anticipating potential issues for my company.	0.846
Economic performance ($\alpha = 0.848, CR = 0.854,$ $AVE = 0.662$)	EOP1. Profit margin exceeds industry average.	0.830
	EOP2. ROI surpasses industry average.	0.745
	EOP3. Revenue growth rate exceeds industry average.	0.861
Social performance ($\alpha = 0.884, CR = 0.885,$ $AVE = 0.659$)	SOP1. High user satisfaction.	0.817
	SOP2. High employee satisfaction.	0.758
	SOP3. High social integrity.	0.821
	SOP4. Compliant with fair competition and tax regulations.	0.848
Environmental performance ($\alpha = 0.870, CR = 0.872,$ $AVE = 0.630$)	ENP1. Resource utilization exceeds industry average.	0.824
	ENP2. Efficiently utilize excess resources.	0.745
	ENP3. Provide high-quality and safe products/services.	0.820
	ENP4. Comply with government environmental policies.	0.783
Sustainable development performance ($\alpha = 0.790, CR =$ 0.833 $AVE = 0.625$)	EOP	0.795
	SOP	0.841
	ENP	0.732

Furthermore, to enhance the validity and reliability of the study's findings by accounting for potential confounding factors, this study conducted the following control variables according to Ren et al. [72]: (1) firm size, which was measured by the total number of full-time employees in the company. (2) firm age was measured as the number of years since the firm was established. (3) TMT experience, measured by the number of years the executive has worked in the TMT.

3.3. Common method bias

Given the utilization of a single-source research design, we implemented multiple strategies to counteract the potential pitfalls associated with Common Method Bias (CMB), as proposed by Podsakoff and Organ [73]. First and foremost, stringent measures were adopted to guarantee the privacy and confidentiality of the respondents during survey administration, aligning with the recommendations of Podsakoff et al. [74]. Secondly, we deployed scales rigorously validated in previous literature, thus minimizing item ambiguity and enhancing content validity. We adjusted the questionnaire while translating it into Chinese based on expert consultation in the relevant field.

To further isolate the effects of CMB, the questionnaire was partitioned into five key sections: Basic Information, MT TMS, OR, OA, and SDP. Each section was prefaced with a succinct introduction to orient the respondent. The division into sections was strategically done to break the monotony and guide the respondent's focus, thereby reducing method variance.

To assess the presence of CMB, Harman's single-factor test was employed, as suggested by Podsakoff et al. [74]. After factor analysis of all variables, six distinct factors with eigenvalues greater than 1 were identified, cumulatively accounting for 69.117 % of the variance. Notably, the first factor accounted for 37.536 % of the variance, which is well below the critical threshold of 50 % [74], thereby providing empirical evidence against the presence of common method factors.

4. Data analysis and results

4.1. Reliability, validity, and correlation analysis

In this study, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were performed using SPSS and AMOS statistical software to assess all the scales. As evidenced by Table 1, the Cronbach's alpha coefficients for all the variables were greater than 0.7, the Composite Reliability (C.R.) values were above 0.8, and the Average Variance Extracted (AVE) values for all variables exceeded 0.5. That indicates that the scales meet the consistency standards of reliability as proposed by Fornell and Larcker [75] and Hair et al. [76]. Subsequently, CFA was conducted on all retained-scale items using AMOS structural equation software. The CFA factor loadings were used to estimate convergent validity. All factor loadings exceeded the recommended value of 0.7 (in Table 1) and were statistically significant at $p < 0.01$, supporting convergent validity as stated by Nunnally [77]. The fit indices showed that the measurement model fit the data well (see Table 2).

This study employs a hierarchical model to understand firm sustainability performance across economic, social, and environmental dimensions. Relying on methodologies from Li et al. [78] and Calantone et al. [79], factor analysis confirmed that these dimensions form a cohesive higher-order construct. Factor loadings varied from 0.745 to 0.861 for the first-order dimensions and were above 0.7 for the second-order construct, validating the model's coherence. Additional fit indices ($\chi^2/df = 2.12$, $CFI = 0.96$, $GFI = 0.95$, $AGFI = 0.92$, $RMR = 0.03$, $RMSEA = 0.06$) further substantiated the model's robustness.

4.2. Correlation analysis

Pearson correlation analysis was performed based on the variables involved after factor analysis to explore the relationships among the main variables in the conceptual framework. As shown in Table 3, there is a significant positive correlation between firm age and size ($B = 0.134$, $p < 0.05$). Similarly, TMT TMS is significantly positively correlated with OR ($B = 0.511$, $p < 0.01$), OA ($B = 0.447$, $p < 0.01$), and SDP ($B = 0.505$, $p < 0.01$). Overall, the variables in this study exhibit relatively close associations, with correlation coefficients ranging from −0.007 to 0.621, suggesting no collinearity issues among the variables. And based on Fornell's [75] postulations, if the squared variance for each construct is higher than its respective row-column correlation coefficients, it indicates robust discriminant validity. As observable in Table 3, the correlation values among the constructs are less than the square root of their respective AVEs, signifying strong discriminant validity within the variables.

4.3. Hypotheses tests

To test the hypotheses, we employed hierarchical multiple regression analysis and the SPSS PROCESS macro developed by Hayes [79]. The macro facilitates streamlined analysis of mediation and moderation in complex models, efficiently estimating model

Table 2
Model fit indices.

	χ^2/df	GFI	AGFI	NFI	CFI	RMR	RMSEA
Model value	1.441	0.892	0.872	0.916	0.972	0.032	0.039
Recommended value	$\geq 1, \leq 3$	≥ 0.8	≥ 0.8	≥ 0.9	≥ 0.9	≤ 0.05	≤ 0.08

Table 3
Correlation matrix and descriptive statistics.

	Mean	S.D.	1	2	3	4	5	6	7
1. Firm age	2.560	0.606	1.000						
2. Firm size	5.649	0.837	0.134*	1.000					
3. TMT experience	1.189	0.614	0.312**	0.103	1.000				
4. TMT TMS	4.066	0.696	0.164**	0.148*	0.195**	**0.774**			
5. OA	3.856	0.993	0.186**	0.035	0.190**	0.447**	**0.856**		
6. OR	3.953	0.809	0.125*	−0.007	0.124*	0.511**	0.314**	**0.814**	
7. SDP	4.001	0.628	0.147*	0.083	0.213**	0.505**	0.304**	0.621**	**0.791**

Note: $*p < 0.05$; $**p < 0.01$; S.D.: standard deviation. The diagonal values are square roots of AVE.

coefficients and effects, and generating bootstrap confidence intervals [80,81]. Under the control of potential influencing factors such as company age, size, and TMT experience, we conducted two hierarchical regression analyses with SDP and OR as the outcome variables, respectively. As shown in Table 4, there was a positive correlation between TMS and SDP (B = 0.479, t = 9.212, p < 0.001). A positive relationship was also found between TMT TMS and OR (B = 0.517, t = 9.094, p < 0.001). Essentially, both hypothesis 1 and 2 have been supported. Additionally, OA had a positive moderating effect on the relationship between TMT TMS and OR (B = 0.174, t = 3.834, p < 0.001).

Furthermore, we carried out a simple slopes analysis employing SPSS PROCESS macro-Model 1. As depicted in Fig. 2, it demonstrates that when OA levels are high (M+1SD), the predictive effect of TMT TMS on OR is significantly positive (*simple slope* = 0.692, t = 8.671, p < 0.001, 95% CI [0.535, 0.849]). Synonymous with the low levels of OA (M−1SD), although TMT TMS continues to predict OR positively, the effect size is significantly reduced (*simple slope* = 0.343, t = 5.269, p < 0.001, 95% CI [0.215, 0.471]). These findings suggest that the level of OA amplifies the predictive effect of TMT TMS on OR. Based on the abovementioned analysis, Hypothesis 4 receives robust empirical support.

And, in the study, we employed the SPSS PROCESS macro-Model 4 to investigate whether OR mediates the relationship between TMT TMS and SDP, while controlling for potential confounders such as firm age, firm size, and the experience of the TMT. According to the results in Table 4, again the predictive ability of TMT TMS on SDP was found to be significant (B = 0.479, t = 9.212, p < 0.001). Notably, even after the inclusion of OR as a mediating variable, the direct effect of TMT TMS on SDP remained significant (B = 0.226, t = 4.309, p < 0.001). These observations were further substantiated by the 95% confidence intervals calculated using the bootstrap method (sample size = 5000), which did not include zero for both the direct (effect = 0.226, bootSE = 0.092, 95% CI [0.058, 0.417]) and indirect effects (indirect effect = 0.263, bootSE = 0.053, 95% CI [0.154, 0.36]), as indicated in Table 5. Accordingly, hypothesis 3 is supported.

In addition, we employed Hayes' [80] PROCESS macro-Model 7 with 5000 bootstrap samples, which assumes that the first half of the mediation model is subject to a moderating variable, aligning with the theoretical framework of this study. In line with hypothesis 4a, the data suggest a significant moderated mediation effect of OA on the relationship between TMT TMS and SDP through OR. Specifically, the conditional indirect effects of TMT TMS on SDP at different levels of OA were all significant and positive (see Table 6). When OA was one standard deviation below the mean, the indirect effect was 0.169 (95% CI [0.055, 0.28]). This effect increased to 0.254 (95% CI [0.146, 0.374]) at the mean level of OA and further strengthened to 0.340 (95% CI [0.183, 0.538]) when OA was one standard deviation above the mean. The index of moderated mediation was 0.086, with a 95% confidence interval excluding zero (0.013, 0.202), confirming that OA significantly moderates the indirect effect of TMT TMS on SDP through OR. These findings support the notion that the effectiveness of TMT TMSin contributing to SDP is contingent upon the level of OAwithin the top management team. Hence, hypothesis 4a in this study is supported.

5. Discussion

This study is based on the RBV and DCV theories and adopts a "resource-capability-performance" research framework. The aim is to explore the direct impact of TMT TMS on SDP, investigate the mediating role of OR between TMT TMS and SDP, and examine the moderating effect of OA on the relationship between TMT TMS and SDP. The findings of the data analysis provide the following conclusions.

First, in line with our research hypothesis, TMT TMS positively impacts corporate SDP (H1). That implies an effective TMT TMScan enhance sustainable development within an organization, supporting achieving favorable performance outcomes. As noted by Tomšič et al. [82], leadership plays a crucial role in integrating sustainability as a strategic component of the organization. The TMS, as a mechanism for knowledge sharing and collaborative learning, strengthens the leadership team's overall capabilities and decision-making quality, enabling the integration of economic, social, and environmental performance to realize the organization's vision. The viewpoint of Cotta and Salvador [83] on integrating information and knowledge within organizations to enhance resilience capability also supports this hypothesis.

Second, the results of this study demonstrate that TMT TMS positively impacts OR (H2). That suggests that by establishing a robust TMS, TMT enhances an organization's adaptability and resistance to better respond to external environmental changes and challenges. Previous studies have primarily focused on TMT characteristics, such as TMT diversity [84], future focus within TMT [85], and TMT

Table 4
Results of regressions.

Variables	Hierarchical multiple regression					Mediation modeling of OR		
	SDP		OR			SDP	OR	SDP
Constant	−1.061 * (−2.444)	−0.333 (−0.853)	−0.403 (−0.914)	0.401 (1.031)	0.42 (1.105)	−0.333 (−0.853)	0.378 (0.969)	−0.519 (−1.521)
Firm age	0.137 (1.378)	0.058 (0.652)	0.163 (1.607)	0.061 (0.695)	0.054 (0.627)	0.058 (0.652)	0.077 (0.875)	0.02 (0.254)
Firm size	0.063 (0.919)	−0.004 (−0.072)	−0.035 (−0.505)	−0.102 (−1.68)	−0.109 (−1.836)	−0.004 (−0.072)	−0.108 (−1.77)	0.049 (0.909)
TMT experience	0.295 ** (3.012)	0.177 * (2.032)	0.157 (1.574)	0.017 (0.197)	−0.015 (−0.173)	0.177 * (2.032)	0.03 (0.346)	0.163 * (2.133)
TMT TMS		0.479 *** (9.212)		0.473 *** (8.294)	0.517 *** (9.094)	0.479 *** (9.212)	0.514 *** (9.897)	0.226 *** (4.309)
OR								0.492 *** (9.572)
OA				0.097 (1.712)	0.139 * (2.464)			
TMT TMS × OA					0.174 *** (3.834)			
R	0.235	0.519	0.156	0.528	0.56	0.52	0.52	0.67
R^2	0.055	0.270	0.024	0.279	0.314	0.27	0.27	0.45
F (*df*)	5.651 (3)***	84.867 (1)***	2.423 (3)	50.771 (2)***	14.697 (1)***	26.68 (4) ***	26.91 (4) ***	46.36 (5) ***

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$; N = 294.
Unstandardized coefficients and t-values (in parentheses) are reported.

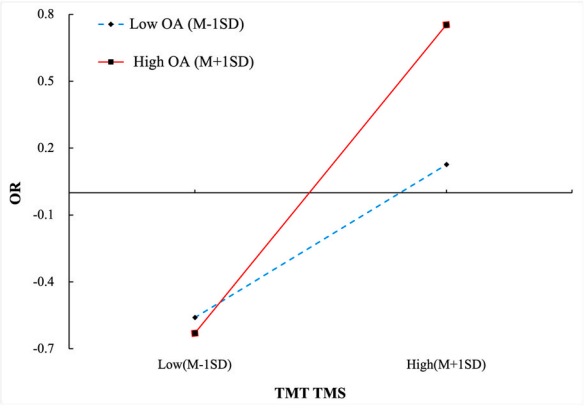

Fig. 2. Plot of the interaction between TMT TMS and OA on OR.

Table 5
The mediator of OR (Bootstrapping test).

IV-M-DV	Coefficient	S.E.	Bootstrapping	
			LL-CI 95 %	UL-CI 95 %
Total effect	0.479	0.076	0.333	0.633
Indirect effect	0.263	0.053	0.154	0.36
Direct effect	0.226	0.092	0.058	0.417

Table 6
Results of moderated mediation analysis.

Conditional indirect effect of TMT TMS on SDP moderated by OA				
Mediator	Moderator	Conditional indirect effect		
	OA	Effect	LL-CI95	UL-CI95
OR	-1SD	0.169 (0.058)	0.055	0.28
	Mean	0.254 (0.059)	0.146	0.374
	+1SD	0.340 (0.090)	0.183	0.538
Index of moderated mediation				
Moderator	Coefficient	S.E.	LLCI95	UCI95
OA	0.086	0.048	0.013	0.202

Note: The number of bootstrap samples = 5000; LL/UL-CI: lower/upper-level bias-corrected 95 % class intervals.

behavioral integration [23], in exploring the relationship between TMT and OR. This study provides a more comprehensive and substantive explanation by focusing on TMT's TMS. As a mechanism for information sharing and knowledge integration, the TMS facilitates communication and collaboration among team members, enhances understanding of internal and external information and trends, and enables the formulation of appropriate response strategies.

Third, this study reveals the mediating role of OR between TMT TMS and organizational SDP (H3). That indicates that TMT TMS influences SDP by positively impacting OR. This finding highlights the importance of OR in achieving sustainable development and emphasizes the critical role of TMT TMS in shaping OR. A well-developed TMT TMS enhances an organization's efficiency, scope, and flexibility, thereby strengthening the acquisition and utilization of specialized knowledge possessed by individual members and expanding the breadth of knowledge available to the organization [86]. Additionally, it enhances the organization's ability to reconfigure and integrate knowledge [86]. Lengnick-Hall et al. [43] emphasize that an organization's capacity for resilience depends on a combination of knowledge, skills, abilities, organizational routines, and processes to navigate disruptive shocks effectively. This study empirically demonstrates the influence of one capability (TMT TMS) on another capability (OR) and their combined impact on organizational performance.

Furthermore, this study reveals the moderating effect of OA on the relationship between TMT TMS and OR (H4). Specifically, increasing (decreasing) OA strengthens (weakens) the relationship between TMT TMS and OR. That suggests that when the TMT members is alert to opportunities, the link between TMT TMS and OR strengthens, further enhancing the organization's adaptability and resistance.

Lastly, the research results confirm the positive mediating effect of OR on the relationship between TMT TMS and organizational SDP, which is further moderated by OA (H4a). Specifically, as OA increases (decreases), the indirect effect of TMT TMS on SDP through OR is strengthened (weakened). These findings further illustrate the importance of top management's OA as an important boundary

condition, as it influences the predictive effects of organizational capabilities on SDP by "influencing individuals' awareness, assessment, and orientation toward uncertainties in the external environment to recognize business opportunities" [60](p. 1108).

6. Conclusion

This study further substantiates the positive impact of TMT TMSon SDP, enriching the theoretical framework of TMSand providing robust theoretical support for managerial practices aimed at sustainable corporate growth. Importantly, this research reveals the mediating role of OR in the relationship between TMT TMS and SDP, with OA exerting a significant moderating effect on this mediation. That indicates that TMTs are more likely to achieve sustainable corporate growth by bolstering OR with increased OA. Moreover, this conclusion incites deeper contemplation on how TMT members can employ their TMS to adapt to a continually evolving business landscape. The OA of TMT members not only aids in seizing external environmental opportunities but also facilitates more efficient internal knowledge and resource utilization, thereby enhancing OR and sustainable development capabilities.

6.1. Theoretical implication

This study significantly contributes to the existing literature on SDP, RBV, and DCV. Firstly, by examining SDP through the lens of the firm's TMT TMS, we address a perspective that has thus far been overlooked. While existing studies have investigated the importance of executive support for firms to achieve sustainable development [22], it remains unclear whether and how TMT TMSenhances a firm's SDP. Our study fills this gap. It adds an essential dimension to our understanding of how the collective wisdom of company leadership can significantly impact the firm's SDP.

One of our research's most significant contributions lies in the proposed integrated theoretical framework. We introduce TMT TMS as a unique, idiosyncratic "cospecialized asset" within the firm that aligns with RBV's focus on difficult-to-imitate resources [86](p. 1377). We then move beyond the static concept of resources to delve into dynamic capabilities. Here, TMT TMS serves as an organically evolving capability that allows for knowledge acquisition, recombination, and integration [87]. This conceptual synthesis bridges the RBV and DCV paradigms in a novel manner, offering fresh insights into the interplay of static resources and dynamic capabilities.

This study further elucidates the role of OR as a mediating variable in the causal chain between TMT TMS and SDP. Moreover, OA serves as a moderating variable, outlining the dynamic conditions under which TMT TMS has the most effective impact on OR and, consequently, on SDP. These dual mechanisms deepen our understanding of the "resource-capability-performance" research framework. Specifically, we posit that OA adds dimensions of context and dynamism to the traditional "resource-capability-performance" framework, and by emphasizing the boundary conditions that affect strategic management decisions, our study extends the existing literature.

By exploring the boundary conditions affecting the impact of TMT TMS on SDP, our research directly addresses the call from Klier et al. [88] for studies investigating contingencies that may influence strategic management theories. We demonstrate that OA is an imperative, conditional factor for fully utilizing the utility of TMT TMS, thus aiding in focusing research on conditional variables beneficial for both the RBV and DCV. This empirical contribution serves as a foundation for future research to further unravel the complexities of strategic management under varying contextual settings.

Lastly, this study reinforces how OA aids organizations in dynamically allocating both internal and external resources. By recognizing and responding to environmental opportunities, firms can effectively shape and improve their dynamic capabilities, enabling more robust and adaptable pathways to sustainable development.

6.2. Managerial implication

In today's complex business environment, the role of the TMTs extends beyond merely making effective decisions, and which has become crucial in shaping and promoting an organizational culture that fosters OR and SDP, accordingly. Particularly in manufacturing enterprises in China, this culture must be strictly aligned with long-term strategic imperatives. The strategic alignment between knowledge management and organizational goals is vital for improving performance and sustainable development [89]. That aligns well with the RBV and DCV, which advocate for integrating internal resources and capabilities with strategic objectives. To implement this culture, introducing a TMS as a tool for knowledge management provides a valuable mechanism for encouraging internal knowledge sharing and collaborative learning [13,34,40,90]. Consequently, TMTs can use regular team meetings, cross-functional working groups, and other open platforms to share specialized knowledge in crisis management and other essential but specialized domains.

Additionally, this study indicates that OA moderates the relationship between TMT TMS and OR. For executive teams, it is imperative to bolster OR through soft powers such as managerial knowledge and cultivate keen alertness to external information among organizational members. Individuals with high levels of vigilance are often adept at identifying potential opportunities and acting on them at the right time [56], which is equally applicable to businesses. Manufacturers should foster a sharp insight into new trends, shifts in customer demands, and unmet market niches through systematic market research and data analysis. Additionally, by establishing a broad information exchange network, businesses can enhance their potential to recognize opportunities through diverse channels of emerging information.

Finally, the TMT must establish feedback loops to ensure the strategic efficacy of the TMS. Key performance indicators could be custom-tailored to measure the effectiveness of this emerging knowledge system. These indicators should go beyond traditional

financial metrics and include the rate of knowledge dissemination, employee engagement in knowledge sharing, and the practical application rate of accumulated knowledge in decision-making processes. In this context, manufacturing firms can establish straightforward yet effective incentive frameworks to encourage employees to contribute and actively utilize the organizational knowledge apparatus. By integrating training programs, seminars, and tools for dynamic scenario planning, the knowledge management system can become a 'living system' that evolves symbiotically with the organization's growth.

6.3. Limitations and future research direction

Firstly, the study's limited scope, either in terms of sample size or industry focus, may restrict the extent to which the results can be applied to different settings or demographic groups. Additionally, while the study examines the relationships between TMT TMS, OR, and SDP, other factors may influence these relationships. It is essential to recognize the complexity of organizational dynamics and consider other potential variables that contribute to SDP. Future research could employ longitudinal studies or experimental designs to provide further insights into the causal nature of these relationships.

Secondly, the study may not account for specific contextual factors that could influence the investigated relationships. Organizational culture, industry-specific dynamics, and macro-environmental factors can all impact the effectiveness of TMT TMS and its impact on SDP. Future studies could explore these contextual factors to gain a more comprehensive understanding.

Another area for improvement in our study concerns the conceptualization of SDP as a second-order construct. In our framework, SDP amalgamates three distinct facets—economic, social, and environmental performance—into a singular measure. The composite nature of this second-order construct may obscure subtler interactions and effects within each dimension, potentially limiting the depth of insights into the multifaceted nature of sustainable development. Our holistic approach to measuring SDP may not fully capture the unique attributes and impacts of its constituent dimensions, which could be meaningful in other research contexts. Future research could consider disaggregating the SDP construct into its dimensions to provide a more detailed understanding of how each contributes to the phenomenon under investigation. Separating these dimensions would allow for a more granular analysis, enriching the research's theoretical and practical implications.

These findings prove that OA moderates the relationship between TMT TMS, OR and SDP. Future research could further investigate other potential moderating variables of this indirect effect, including the market contextual factors, to clarify the boundary effects of TMT TMS.

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Declaration of interest's statement.

The authors declare no conflict of interest related to this study.

Data availability

The data presented in this study is available on Mendeley Data, https://doi.org/10.17632/99khzd2nwc.1.

CRediT authorship contribution statement

Chun-Liang Yao: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Li-Yuan Wang:** Visualization, Validation, Supervision, Resources, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

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

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