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# Impact of Organisational Distance on Technology Standard Alliance Performance: The Mediating Role of Ambidextrous learning

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**Abstract**

Technology standards are key elements for enterprises to dominate a market. The globalisation of innovation has intensified standard competition, making it generally difficult for a single enterprise to obtain all the resources needed to develop standards. Therefore, enterprises actively join technology standard alliances (TSAs) to seek collaborative innovation and develop technology standards to gain more competitive advantages. This study addresses a crucial issue for enterprises in TSAs and attempts to help them overcome the confines of organisational distance (OD) and improve technology standard alliance performance (TSAP). Through an empirical study of 325 Chinese information and manufacturing enterprises participating in TSAs, we find that OD negatively affects TSAP, and that exploratory learning (ERL) and exploitative learning (EIL) play mediating roles in the relationship between OD and TSAP. The innovation climate (IC) plays a moderating role in the relationship between OD and ERL, and OD and EIL. The results might deepen the understanding of OD in the context of TSAs and have implications for enterprise standardisation practices.

**Keywords**

technology standard alliances; organisational distance; ambidextrous learning; innovation climate

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## 1. Introduction

The current era of global competition is characterised by the rapid development of information technology industries such as those involved in artificial intelligence, big data, and cloud computing (Baron *et al*., 2016; Feng *et al*., 2019). Enterprises that proactively shape standard discourse are likely to gain dominant market positions (Liu *et al*., 2012; Ranganathan *et al*., 2018; Spulber, 2019). The currently incomplete global frameworks for international R&D and patents offer many good opportunities to overhaul standards in many industries, with technology standard alliances (TSAs) playing a crucial role in the formulation, implementation, and promotion of standards. TSA participation enables enterprises to develop standards and gain competitive advantages (Leiponen, 2008; Wen *et al*., 2020; Lou *et al*., 2022).

Implementing technology standardisation is an exacting, risk-intensive, and costly process. As standards cannot be formulated by enterprises acting alone (Cohen *et al*., 2016; Wu and de Vries, 2022), TSAs play a crucial role in coordinating the process. They also allow enterprises to establish cooperative relationships with each other and with governments, universities, and research institutions, thereby promoting innovation. The interaction between various members and mechanisms within alliances (Sen and Puranam, 2022) enables TSAs to integrate and optimise their internal and external resources to build competitive advantages and ultimately obtain broader economic and social benefits. However, cultural and institutional differences continue to impact cooperation and communication between organisations, and this objective organisational distance (OD) inevitably hinders performance improvement (Hslao *et al*., 2017). Overcoming the constraints of OD to coordinate the interactive exchange of resources among alliance members has become an urgent focus for enterprises.

OD refers to the differences in institutional traditions and organisational cultures between enterprises and their partners (Simonin, 1997), with most research considering its impact from the perspective of social network theory (Chen and Lin, 2019; Sampath and Rahman, 2019). When formulating technology standards, enterprises must acquire knowledge more than any other resource (Lee, 2021). As OD increases, the interaction issues become increasingly complex. The larger the OD, the more difficult it is for enterprises to agree on behavioural goals with other alliance members. While a larger OD makes obtaining knowledge from partners more difficult, enterprises struggle to fully utilise their resources owing to the differences between the external knowledge they obtain and their organisational principles and systems. In this context, organisational learning is crucial for acquiring and utilising knowledge. Organisational learning includes exploratory and exploitative learning (ERL/EIL; Huang and Li, 2012; Yannopoulos *et al*., 2012; Wang *et al*., 2017), with the former focusing on exploring and acquiring new knowledge and technology, in contrast to the latter's emphasis on applying and deepening existing knowledge and organisational skills. The complementary effect of the two is conducive to formulating technological standards and improving performance (Li and Huang, 2013). In addition, innovation climate (IC) is a core condition of innovation performance (Menzel *et al*., 2007; Martin-de Castro *et al*., 2013). Based on the belief that technology standard alliance performance (TSAP) is a part of innovation performance and that IC affects organisational learning (Cai *et al*., 2019; Wang *et al*., 2023), it is worth investigating whether a positive IC can reduce the distance between organisational members of TSAs.

This study addresses the theoretical gaps and practical issues mentioned above in several ways. First, few studies have placed OD in the context of TSAs to examine the mechanism underlying its impact on performance. Therefore, the present study intends to deepen the current understanding of OD and provide a theoretical basis for guiding improvements in TSAP. Second, analysing the behaviour of alliance enterprises and introducing ambidextrous learning as a mediating variable allow us to explore the effect of OD on TSAP, thereby expanding the scope of research on technology standardisation. Moreover, this study's investigation into the changing role of OD in ambidextrous learning under the boundary conditions of IC enriches the current social network literature. Finally, we hope that this study can guide enterprises dealing with OD in TSAs, helping them establish collaborative mechanisms to improve cooperation, reduce conflicts, and enhance the competitiveness of their technology standards.

The remainder of this paper is organised as follows. The second section reviews the relevant literature from the perspectives of social network and organisational learning theory to construct a theoretical framework of the hypothesised relationships between OD, ambidextrous learning, and TSAP. The third section introduces the sample and research methods. The fourth section presents the results of the empirical analysis and details of the hypothesis validation. Finally, the conclusions, theoretical and practical contributions, and limitations of this study are presented, along with recommendations for future research.

## 2. Theory and Hypotheses

*2.1. Organisational distance and technology standard alliance performance*

Previous research defined TSAs from the perspective of organisational mechanisms, motivations, types, and individual members of standard alliances. Axelrod (1995) defined a TSA as an invisible or explicit alliance established by a company with one or more (potential) competitors to develop and promote a new standard in the absence of an industry leader or when competitive technology emerges. Hu (2023) viewed TSAs as contractual alliance mechanisms formed by firms to reach an agreement on core technologies to share technological achievements and reduce the costs and risks of standardisation. The same author subsequently defined TSAs as loose and temporary alliances of contracted partners formed to complete a specific task. The present study frames TSAs as contracted organisations whose main participants are enterprises that aim to formulate, implement, and diffuse the alliance's standards and finally obtain benefits through them.

Technology standards are developed through the cooperation of parties through alliances (Wu, 2022). Since these standards require close technical compatibility, alliance members must include diverse organisations, such as enterprises from different industries, governments, universities, and scientific research institutions, with each group aiming to gather technical, epistemic, and social resources. This embodies the characteristics of the diversity of the subjects of a technology standard alliance. In the standardisation process, alliance members share their technological achievements, learn from each other, promote knowledge creation and transfer and jointly launch the alliance's standards. Alliance enterprises use the first-move advantage of mastering new standards and technologies to prioritise entering the market and producing and diffusing technologies (Wen, 2020). With the assistance of fellow members, they can upscale the usage of products and improve the overall performance of TSAs (Antoncic and Prodan, 2008), which reflects the characteristics of the network externalities of the TSA.

The concept of OD appears in research exploring the cooperation between multiple subjects in knowledge transfer. Drawing on a range of social network and embeddedness theories, scholars define OD in various ways. Simonin (1997) viewed OD as the difference between the institutional traditions and organisational cultures of two or more partners. Chen *et al*. (2018) classified this into two dimensions: physical/psychic distance and intra-/inter-organisational distance. Ingršt *et al*. (2021) argued that cultural and geographical differences between parent multinational companies and their subsidiaries produce an OD that significantly hinders knowledge flow between them. Wen *et al*. (2019) proposed that in the process of technology standardisation, the differential distribution of knowledge and resources across firms is a valuable heterogeneous resource for alliance members. Drawing on Simonin and Wen's views, this study defines OD in TSAs as the degree of difference between alliance members in terms of knowledge, technology, systems, culture, and other areas. Such differences limit standardisation activities among members and are mainly reflected in knowledge- and norm-based distance.

Most existing studies consider the antecedents of firms' standardisation capabilities but ignore the impact of their participation in TSAs. Researchers and managers have focused on the factors that affect firms' participation in TSAs and how to improve the overall performance of the alliance. Social network theory views the OD between alliance enterprises as a measure of the strength of their relationships. Galaskiewicz (2000) pointed out that the distribution of knowledge within a team and the social relationships amongst its members positively affect team performance (Leonidou *et al*., 2006). While some conflicts are inevitable owing to the heterogeneity of alliance members, OD increases the occurrence of these conflicts, hinders technological development and knowledge transfer, and destabilises the technology standardisation process. Cummings *et al*. (2003) emphasised that OD increases conflicts and disagreement in inter-organisational communication, making it impossible to resolve cooperation problems promptly and disrupting the smooth functioning of alliances. Wilfred and Rene (2016) argued that the distance between organisational participants affects their ability to exchange knowledge and innovate effectively. Monge *et al*. (1985) contended that OD in strategic alliances affects knowledge exchange and transformation within firms, as well as their ability to cooperate and innovate. OD is negatively related to mutual identification and trust among members. Lower OD facilitates knowledge flow and transfer, thus improving the TSAP (Dhanaraj *et al*., 2004; Mohr and Spekman, 1994; Lundquist and Trippl, 2013).

OD has two important aspects. The first is knowledge distance. Technology standards represent a type of explicit knowledge – a normative document formed by different subjects to delimit the relevant products, processes, formats, procedures, and other elements to meet users' expectations of a consistent technical paradigm (Tassey, 2000). Technology standardisation thus rests on the flow of knowledge and technology, with TSAs driving this process. Alliance members are typically composed of units from various industries and have different knowledge and R&D backgrounds. Increasing the epistemic distance between members likely obstructs knowledge acquisition, which in turn reduces the efficient formulation of standards and damages the alliance's performance.

The second aspect of OD is norm distance, which describes the extent to which alliance members differ in their organisational cultures and values. The organisational culture and values of an enterprise determine its internal systems, behavioural norms, and work styles (Tushman, 1977). When alliance members share similar organisational cultures and value systems, they benefit from smoother cooperation. However, when cultures and systems differ, tasks are understood differently, members struggle to identify with each other, and task-related information exchange becomes difficult. When alliance standards are implemented and diffused, products must be based on these standards so that companies can enter and rapidly expand their market share. Differences in organisational cultures and values distinguish companies' cognitive habits, ideas, and opinions and reduce mutual trust, making it difficult to maintain consistent actions under fierce market competition, which greatly reduces alliance performance.

From the perspective of social networks, a close relationship between alliance enterprises will make the two sides treat each other sincerely and benefit each other, and they will be more willing to think of their partners in the process of cooperation, thus reducing the theft of core knowledge to maintain a lasting cooperative relationship. However, when there are conflicts between alliance partners, the opportunistic behaviour of alliance partners will increase, which will reduce trust between alliance enterprises, thus leading to a decline in intimacy (Becerra *et al*., 2008). Thus, the OD between TSA members hinders their respective advantages and reduces the possibility of obtaining favourable resources from the alliance. The differences between enterprises cause conflicts and contradictions, thus affecting an alliance's overall performance. We therefore propose the following hypothesis:

*H1. There is a negative relationship between OD and TSAP.*

### *2.2. The mediating role of ambidextrous learning*

Organisational learning theory holds that strategic alliances enable enterprises in different fields to innovate by learning from each other, linking new information, building their ability to identify opportunities, and obtaining sustainable competitive advantages (Zollo and Winter, 2002; Ali, 2021). March (1991) divided organisational learning into exploratory (ERL) and exploitative (IRL) approaches, which are now widely understood as attributes of ambidextrous learning (Lee, 2013). In this study, ambidextrous learning refers to the process of active participation in TSAs and the exchange of knowledge and information resources. ERL refers to the behaviour involved in the organisational acquisition of new knowledge and resources through search, learning, and research processes to enhance innovation. It requires close cooperation with external organisations to acquire knowledge and resources that differ from those currently circulating in an enterprise.

EIL aims to improve the efficiency of organisational operations by transforming and applying existing knowledge through the processes of screening, condensation, and implementation (Bierly *et al*., 2009). It entails gradual change and reform of existing organisational knowledge and resources, and the knowledge acquired is relatively simple. In this context, alliances can be viewed as platforms connecting enterprises to external sources of knowledge (Inkpen, 1995). Alliances improve members' performance by enabling them to acquire knowledge from other organisations and drive innovation through organisational learning (Park, 2010). Overall, these two approaches to ambidextrous learning (ERL and EIL) emphasise the acquisition and utilisation of different types of knowledge resources. This study investigates how firms in TSAs break through the boundaries of inter-organisational knowledge and norms through ambidextrous learning, which we expect to mediate the negative effects of OD on alliance performance.

The high-level performance of TSAs depends on effective cooperation amongst their members. Alliance enterprises whose knowledge, R&D background, organisational cultures, and systems differ may struggle to interact, couple their knowledge, or learn properly (Belderbos *et al*., 2020). As Gaur (2019) and Lee (2022) emphasised, they will struggle to use each other's knowledge to develop innovative solutions. Increased distance in organisational knowledge multiplies the required learning steps. While a certain degree of knowledge redundancy and professional overlap is conducive to knowledge transfer and flow, firms cannot identify the steps required to learn from their partners when the skill gap between them and their partners is large (Hamel, 1991). ERL aims to expand organisational knowledge by recognising and acting on knowledge from new fields. Through continuous trial-and-error, an enterprise breaks free from dependence on its original path, reconstructs its knowledge resources, and develops new technologies.

When standardising technologies, alliance members must share the costs and risks of trial-and-error exploration; however, OD directly reduces their willingness to input, exchange, and learn knowledge, ultimately weakening their enthusiasm for ERL.

The EIL emphasises the process of condensing and transforming existing domain knowledge. It aims to enhance the depth of organisational knowledge by supporting full communication with allied partners to absorb product technologies, management approaches, and knowledge of other relevant domains. However, when another organisation's culture, systems, and values are perceived to differ from one's own, trust and identification become more difficult to establish. This leads to further contradictions and conflicts between enterprises, increasing coordination costs, and weakening their willingness to engage in EIL. Moreover, cultural and institutional differences are inconducive to EIL because they may make enterprises sceptical about available knowledge, further hindering its exchange, application, and recreation.

Nonetheless, organisational learning plays a pivotal role in improving alliance performance. The success of allied enterprises depends on their ability to master scarce resources and continuously acquire and utilise new knowledge through organisational learning to develop a competitive advantage (Lloria, 2014; Shan, 2018). Inkpen (1997) argues that a reduced capacity for organisational learning and knowledge absorption impacts the bargaining power of alliance partners, thereby lowering alliance performance. Simonin (1997) found that, in the context of strategic alliances, technological knowledge acquired from past collaborative experiences benefitted the firm in its current alliance. By exchanging epistemic resources and continuously filtering and refining effective knowledge through organisational learning, allied members can grasp future developments and improve their alliance performance.

However, few studies have investigated the effects of particular aspects of organisational learning on alliance performance. Benner (2003) and Yalcinkaya (2007) found that enterprises accumulate heterogeneous knowledge and technology through ERL. The infusion of new knowledge stimulates the creativity of firms' R&D teams, generating more promising innovations and helping them meet diverse market needs. Furthermore, EIL deepens an enterprise's understanding of existing knowledge by upgrading it and expanding the scope of its application (Menguc and Auh, 2010). The knowledge and informational resources obtained from ambidextrous learning provide a foundation for standardisation. Schildt (2005) argues that EIL based on existing products and market experience can help enterprises understand consumer preferences, adjust their R&D and production directions over time, and improve operational efficiency. Ambidextrous learning fosters cooperation among alliance members, avoids potential risks in implementing and diffusing alliance standards, and improves TSAP.

In summary, the literature suggests that differences in knowledge, technologies, institutions, and cultures within a TSA constrain the smooth implementation of technology standardisation activities and prevent them from achieving expectations. However, ambidextrous learning can effectively break through the macro-boundaries between alliance members. ERL prompts enterprises to search for heterogeneous knowledge sources within the alliance; this expanded scope helps them remove knowledge boundaries with other organisations. EIL encourages enterprises to absorb the organisational experience of other members, bridge the norms that separate them, and alleviate conflicts and contradictions caused by OD in the standardisation process. Therefore, ambidextrous learning may affect the relationship between OD and TSAP by ameliorating the negative effects of the former and promoting performance improvement in the latter. Accordingly, we propose the following hypothesis:

*H2. ERL mediates the relationship between OD and TSAP.*

*H3. EIL mediates the relationship between OD and TSAP.*

*2.3. The moderating effect of innovation climate (IC)*

Organisational climate refers to employees' perceptions of their organisational environments. Schneider (1983) argued that various organisational climates, such as the IC, must be defined before they can be discussed meaningfully. Zhang (2022) defined IC as the degree of support for innovation and creativity perceived by organisational members in an organisational environment. According to Sarros (2008), IC denotes the degree to which organisations encourage employees to explore innovative approaches to their initiative. These two viewpoints define IC from the perspective of employees' subjective experiences and objective work environments. This study takes the "subjective" perspective on IC based on employee perceptions of organisational support for innovation. In the technology standardisation process, as a "soft environment" of the enterprise, organisational IC, in which managers support innovation and tolerate failure, can effectively encourage employees to constantly try, discover, and explore external knowledge in new fields, conceive new ways to solve problems, and increase the original knowledge reserve of the organisation. Thus, it is a key situational factor in the willingness of alliance members to participate in organisational learning and can moderate the negative effects of OD on ambidextrous learning.

The significance of IC has been emphasised in the literature. Strong IC can promote the effective integration and utilisation of knowledge resources while also facilitating ambidextrous learning (Gupta, 2006). Lisboa (2011) found that a corporate culture of innovation significantly impacts both exploratory and exploitative product development. Employees perceive a firm with a strong culture of innovation as maintaining open and inclusive attitudes towards innovation; thus, it supports experimentation with new ideas, is willing to bear the costs and risks of the trial-and-error and experimentation process, and accepts that failure will sometimes occur (Barreto, 2010; Wei, 2014). ERL focuses on the search for knowledge and technology outside the enterprise boundaries, and its results are often difficult to measure in detail. Therefore, this atmosphere helps employees actively explore new areas of knowledge, reroute existing learning paths, effectively promote the reorganisation and reconstruction of knowledge resources, and relieve the uncertainty generated by organisational differences, thus facilitating enterprise ERL. In other words, a strong IC weakens the negative impact of OD on ERL.

In addition, as the climate of innovation among allied enterprises continues to improve, interactions between members become more frequent and timelier, thereby promoting knowledge sharing and information exchange, and eliminating attempts to conceal knowledge (Argote and Hora, 2016; Xiong, 2021), and helping enterprises acquire technology, management experience, and knowledge from other related fields. EIL focuses on the re-integration and re-creation of existing knowledge and experience. Therefore, in such an atmosphere, enterprises do not abandon their original practices and work styles but rather reform them (Lumpkin, 1996). For alliances, this builds trust, consolidates a strong organisational identity, and reduces the contradictions and conflicts between members that typify OD, thereby facilitating exploratory learning within enterprises. Based on this, we propose the following hypothesis:

*H4. The IC negatively moderates the relationship between OD and ERL. In other words, the stronger the IC, the weaker the relationship between OD and ERL.*

*H5. The IC negatively moderates the relationship between OD and exploitative learning. In other words, the stronger the IC, the weaker the relationship between OD and EIL.*

Figure 1 depicts our theoretical TSAP model with OD as the antecedent variable, ambidextrous learning as the mediating variable, and IC as the moderating variable.

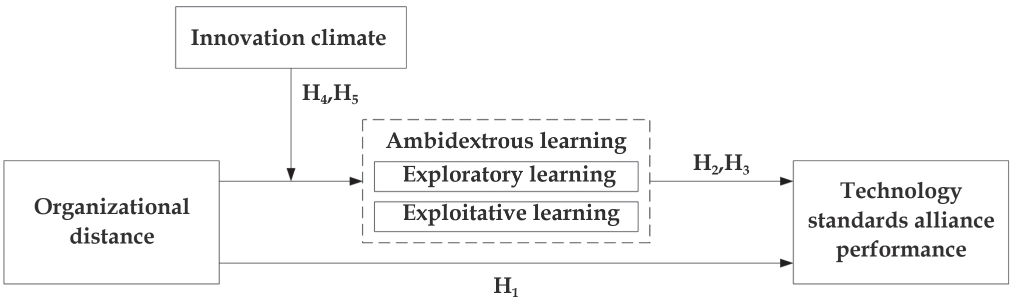


**Fig. 1.** Conceptual model of OD on TSAP.

## 3. Data and Methodology

*3.1. Sample and data collection*

This study is based on the practice of TSAs in the context of the globalisation of innovation. Therefore, we must select industries with a high degree of standardisation, a high degree of industry aggregation, and a far-reaching impact at the national strategic level. Currently, the information industry is the most active technological innovation field. Governments attach considerable importance to the development and promotion of information technology standards. Alliances formed around information technology standards are already widespread, and empirical studies based on the industry can provide valuable insights into the effective functioning of TSAs (Keil, 2002; Rice and Galvin, 2006; Tafti *et al*., 2013; Gerges-Yammine and Ter, 2023). In the context of China's transformation between old and new energy sources, the information industry continues to introduce new momentum into the development of the manufacturing industry, thus creating more opportunities for standardisation. The manufacturing industry has become the main international battlefield for economic and standard-based competition. Several studies focused on manufacturing-related TSAs (Blind and Mangelsdorf, 2016; Wen *et al*., 2020). Therefore, the information and manufacturing industries were particularly well suited for investigating the areas emphasised in the present study. Data were collected using questionnaires. To ensure data reliability, we applied strict criteria to select specific sample enterprises. We piloted the questionnaire to ensure that the respondents clearly understood the items and corrected any unclear language. A total of 400 questionnaires were collected, 325 of which were deemed valid.

*3.2. Measurement of variables*

To ensure that our data were reliable and valid, we adapted existing scales from previous domestic and international studies. A 7-point Likert-type scale (1=totally agree; 7=totally disagree) was used to measure four constructs: OD, ambidextrous learning, IC, and TSAP. Following Simonin (1997) and Hsiao *et al*. (2017), OD was measured using two items. Ambidextrous learning was measured using versions of instruments presented by Atuahenegima *et al*. (2007) and Chung *et al*. (2015), who assessed ERL and EIL using five items. Finally, IC was measured using the four items presented in Popa and Oke (Popa *et al*., 2017; Oke *et al*., 2013) and the TSAP using the four items provided by Zhou *et al*. (2011) and Das *et al*. (2003). The details of these items are listed in Table 1.

*3.3. Descriptive statistics*

Before empirically testing the variables in this study, descriptive statistics were first analysed on the characteristics of the collected samples (see Table 2). In terms of enterprise size, enterprises with 200 to 499 employees accounted for 28.92 per cent of the total sample. In terms of the type of industries in which

**Table 1**
Variables and measurements.

| Variables | Items | References |
|---|---|---|
| Organisational distance (OD) | ● The business practices and operational mechanisms are very similar to those of your alliance partners.<br>● The corporate culture and management are very similar to those of your partners. | Simonin (1997)<br>Hsiao *et al.* (2017) |
| Exploratory learning (ERL) | ● Your enterprise values the acquisition of strategic knowledge of products/services that involve experimentation and high market risk.<br>● Your enterprise tends to be untargeted in gathering information on strategic market needs with a view to ensuring experimentation in the development of new products and services.<br>● Your enterprise develops products/services with the aim of acquiring knowledge, which leads to new knowledge such as new markets and technological experience.<br>● Your enterprise collects new information beyond its existing market and technological experience.<br>● The goal of your enterprise is to gather new information that compels it to learn new knowledge in the development of new products and services. | Atuahenegima *et al.* (2007)<br>Chung *et al.* (2015) |
| Exploitative learning (EIL) | ● The goal of your enterprise is to search for information and improve methods and ideas for solving new product/service development problems.<br>● The goal of your enterprise is to search for ideas and information that will ensure productive capacity.<br>● Your enterprise looks for commonly used and proven methods and programmes to address new product/service development issues.<br>● Your enterprise uses information-gathering methods (e.g., surveys of current customers and competitors) to help it understand and update its current product/service market experience.<br>● Your enterprise emphasizes the use of knowledge related to existing product/service experience. | |
| Technology standard alliance performance (TSAP) | ● Joining technology standard alliances can reduce your enterprise's operating costs.<br>● Joining technology standard alliances can increase the sales for your enterprise.<br>● Joining technology standard alliances can reduce the risk of technology development in your enterprise.<br>● Joining technology standard alliances can increase the exchange of learning between your enterprise and industry peers. | Zhou *et al.* (2011)<br>Das *et al.* (2003) |
| Innovation climate (IC) | ● Your enterprise provides time and resources for employees to generate, share/communicate and test innovative ideas/solutions.<br>● Employees in your enterprise work in work groups with different skills and there is free and open communication between group members.<br>● Employees in your enterprise often encounter unconventional and challenging tasks that stimulate creativity.<br>● Employees in your enterprise are recognized and rewarded for their creativity and innovative ideas. | Popa *et al.* (2017)<br>Oke *et al.* (2013) |

the alliance enterprises are located, the majority of them are manufacturing enterprises, accounting for 64 per cent of the total. In terms of the ownership of enterprises, private sectors accounted for the largest proportion of 64.92 per cent. In the age distribution of enterprises, the number of enterprises that have survived for more than 20 years is the largest, reaching 93. Also, the means, standard deviation, minimum and maximum values of variables are reported in Table 3.

*3.4. Reliability and validity tests*

The reliability of the scale was tested using SPSS 26.0, and the results are presented in Table 4. A Cronbach's α value greater than 0.7 generally indicates acceptable results. In this study, the Cronbach's α values of the 5 constructs were all greater than 0.7: OD = 0.865, ERL = 0.860, EIL = 0.883, TSAP = 0.881, and IC = 0.889, respectively. Therefore, the reliability of the survey questionnaire was acceptable.

**Table 2**
Descriptive statistics of sample characteristics.

| Characteristics | Category | Sample size | Proportion (%) |
|---|---|---|---|
| Size | Less than 100 people | 32 | 9.85 |
| | 100–199 people | 41 | 12.62 |
| | 200–499 people | 94 | 28.92 |
| | 500–1000 people | 78 | 24.00 |
| | More than 1000 people | 80 | 24.62 |
| Industry | Manufacturing industry | 208 | 64.00 |
| | Information industry | 117 | 36.00 |
| Ownership | State-owned enterprise | 69 | 21.23 |
| | Joint venture | 24 | 7.38 |
| | Foreign company | 20 | 6.15 |
| | Private sector | 211 | 64.92 |
| | Others | 1 | 0.31 |
| Age | 5 years and below | 17 | 5.20 |
| | 6–10 years | 72 | 22.20 |
| | 11–15 years | 70 | 21.50 |
| | 16–20 years | 73 | 22.50 |
| | More than 20 years | 93 | 28.60 |

*Note: Total number of the sample (N) = 325.*

**Table 3**
Summary statistics of variables.

| Variables | Items | Mean | s.d. | Min | Max |
|---|---|---|---|---|---|
| Size | 5 | 3.41 | 1.26 | 1.00 | 5.00 |
| Industry | 2 | 1.36 | 0.48 | 1.00 | 2.00 |
| Ownership | 5 | 3.16 | 1.25 | 1.00 | 5.00 |
| Age | 5 | 3.47 | 1.26 | 1.00 | 5.00 |
| OD | 2 | 4.92 | 1.18 | 1.00 | 7.00 |
| ERL | 5 | 5.47 | 0.91 | 2.00 | 6.80 |
| OD | 2 | 4.92 | 1.18 | 1.00 | 7.00 |
| ERL | 5 | 5.47 | 0.91 | 2.00 | 6.80 |
| EIL | 5 | 5.64 | 0.97 | 1.40 | 7.00 |
| TSAP | 4 | 5.69 | 0.99 | 1.50 | 7.00 |
| IC | 4 | 5.27 | 1.30 | 1.50 | 7.00 |

*Note: Total number of the sample (N) = 325.*

Based on the theoretical model and measurement scale, AMOS 24.0 was used to establish the structural equation model, confirmatory factor analysis was carried out to obtain the standardised loading of the factors, and the corresponding AVE and CR values of each factor were calculated. We have 2/df = 1.375 (< 3), RMSEA = 0.034 (< 0.08), GFI = 0.935 (> 0.9), NFI = 0.944 (> 0.9), IFI = 0.984 (> 0.9). These results show that the theoretical model has a high degree of fit with the actual data and high structural validity.

**Table 4**
Reliability and validity analysis.

| Variables | Items | Loadings | AVE | CR | Cronbach's α |
|---|---|---|---|---|---|
| OD | OD1 | 0.903 | 0.7639 | 0.8660 | 0.865 |
| | OD2 | 0.844 | | | |
| ERL | ERL1 | 0.736 | 0.5516 | 0.8601 | 0.860 |
| | ERL2 | 0.762 | | | |
| | ERL3 | 0.749 | | | |
| | ERL4 | 0.733 | | | |
| | ERL5 | 0.733 | | | |
| EIL | EIL1 | 0.783 | 0.6023 | 0.8833 | 0.883 |
| | EIL2 | 0.773 | | | |
| | EIL3 | 0.779 | | | |
| | EIL4 | 0.788 | | | |
| | EIL5 | 0.757 | | | |
| TSAP | TSAP1 | 0.804 | 0.6485 | 0.8806 | 0.881 |
| | TSAP2 | 0.781 | | | |
| | TSAP3 | 0.838 | | | |
| | TSAP4 | 0.797 | | | |
| IC | IC1 | 0.856 | 0.6742 | 0.8919 | 0.889 |
| | IC2 | 0.777 | | | |
| | IC3 | 0.769 | | | |
| | IC4 | 0.877 | | | |

Table 4 presents the results of aggregate validity analysis. A standardised loading of a factor greater than 0.5, an AVE value greater than 0.5, and a CR value greater than 0.7 indicate acceptable data. The factor loading of each variable measurement index ranged from 0.733 to 0.903 and the AVE value ranged from 0.5516 to 0.7639, indicating that the measurement items of each latent variable had good aggregation validity. The results of the discriminative validity tests are presented in Table 5. The square root of the AVE value of each latent variable is greater than the correlation coefficient of the latent variable and other variables; therefore, the variables have discriminative validity. Therefore, the sample has good discriminant validity among the variables.

*3.5. Common methodology bias*

To check whether the measurement results were affected by common method bias, the logic and objectives of the research were not explained in detail in the questionnaire design. Second, to avoid the influence of causality, an anonymous method was adopted to ensure that the questionnaires reflected

**Table 5**
Correlation coefficient and the square root of AVE value.

| | Size | Industry | Ownership | Age | OD | ERL | EIL | TSAP | IC |
|---|---|---|---|---|---|---|---|---|---|
| Size | 1.0000 | | | | | | | | |
| Industry | -0.183 | 1.0000 | | | | | | | |
| Ownership | -0.251 | -0.002 | 1.0000 | | | | | | |
| Age | 0.545 | -0.352 | -0.208 | 1.0000 | | | | | |
| OD | -0.152*** | 0.061 | 0.097** | -0.095** | 0.8740 | | | | |
| ERL | 0.082* | 0.030 | 0.000 | 0.095** | -.203*** | 0.7427 | | | |
| EIL | 0.050 | 0.000 | -0.027 | 0.089* | -.212*** | .683*** | 0.7761 | | |
| TSAP | 0.051 | -0.045 | 0.009 | 0.093* | -.283*** | .561*** | .545*** | 0.8053 | |
| IC | -0.095** | 0.07 | 0.112* | -0.014 | .519*** | .215*** | .219*** | .137** | 0.8211 |

*Notes: *P<0.1, **P<0.05, ***P<0.01. The square root of AVE is shown on the diagonal.*

participants' real thoughts. Afterwards, the Harman Single Factor test was used to test the homogeneity of the sample data; that is, all items of the OD, ERL, EIL, IC, and TSAP scales were combined for a non-rotating principal component factor analysis. The results show that the first factor before rotation explains 36.79% of the total variance, which is less than 40%, indicating no serious common method bias.

## 4. Empirical Results

*4.1. Direct effect test*

Table 6 reports the regression results of the direct effects of OD, ERL, and EIL on TSAP in the model (see Table 5). Models 5 and 6 explored the direct influence of OD on TSAP. Model 5 examined the influence of control variables on TSAP, and Model 6 added independent variables to the regression equation. The results showed that OD had a significant negative effect on TSAP ($\beta$ = -0.284, p < 0.01), thereby verifying Hypothesis 1.

*4.2. Mediating effect test*

Models 1 to 8 indicate that OD significantly impacted ERL, EIL, and TSAP, whereas ERL and EIL significantly impacted TSAP. This satisfies the first two conditions of Baron and Kenny's (1986) mediating effect test. Therefore, independent, control, and mediating variables can be simultaneously added in the regression model to determine whether a mediating effect was present. Model 9 added the ERL variable to Model 6, with the regression showing that ERL was significantly and positively correlated with TSAP ($\beta$ = 0.526, p < 0.01). Moreover, the negative effect of OD on TSAP remained significant ($\beta$ = -0.179, p < 0.01) but was much smaller than that recorded in Model 6, where it had been -0.284 (p < 0.01). These results indicate that ERL partly mediates the relationship between OD and TSAP, thereby verifying Hypothesis 2. Model 10 was based on Model 6 with the addition of the EIL variable. The regression revealed that EIL and TSAP ($\beta$ = 0.505, p < 0.01) were significantly and positively correlated. The negative effect of OD on TSAP remained significant ($\beta$ = -0.177, p < 0.01) but was substantially lower than its Model 6 value of -0.284 (p < 0.01). This result demonstrates that EIL also partially mediates the relationship between OD and TSAP, thus verifying Hypothesis 3.

**Table 6**
Test results of direct effect and mediating effect.

| Variables | ERL | | EIL | | TSAP | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | Model 9 | Model 10 |
| Size | 0.049 | 0.023 | 0.001 | -0.027 | 0.007 | -0.030 | -0.021 | 0.006 | -0.042 | -0.017 |
| Industry | 0.074 | 0.082 | 0.035 | 0.043 | -0.012 | -0.001 | -0.054 | -0.031 | -0.045 | -0.023 |
| Ownership | 0.034 | 0.047 | -0.006 | 0.008 | 0.029 | 0.048 | 0.010 | 0.033 | 0.023 | 0.044 |
| Age | 0.101 | 0.101 | 0.100 | 0.100 | 0.091 | 0.091 | 0.034 | 0.037 | 0.038 | 0.041 |
| OD | | -0.200*** | | -0.210*** | | -0.284*** | | | -0.179*** | -0.177*** |
| ERL | | | | | | | 0.561*** | | 0.526*** | |
| EIL | | | | | | | | 0.542*** | | 0.505*** |
| **Equation Indicators** | | | | | | | | | | |
| $R^2$ | 0.016 | 0.055 | 0.009 | 0.052 | 0.010 | 0.088 | 0.319 | 0.300 | 0.349 | 0.330 |
| Adj-$R^2$ | 0.004 | 0.040 | -0.003 | 0.037 | -0.003 | 0.073 | 0.308 | 0.290 | 0.337 | 0.317 |
| F | 1.286 | 3.681 | 0.733 | 3.492 | 0.774 | 6.135 | 29.887 | 27.407 | 28.389 | 26.079 |

*Notes: * P<0.1, ** P<0.05, *** P<0.01.*

*4.3. Moderating effect test*

The product terms of the independent and moderating variables were then introduced into the regression equation (see Table 7). Model 11 added IC as a moderating variable based on Model 2, whereas Model 12 added an interaction term between OD and IC, based on Model 11. The product term of OD and IC had a significant effect on ERL ($\beta$ = 0.170, p < 0.05), indicating that IC significantly moderated the linkage between OD and ERL: the stronger the IC, the weaker the negative relationship between OD and ERL. Thus, the results verify Hypothesis 4. Finally, Model 13 added IC as a moderating variable based on Model 4, and Model 14 added an interaction term between OD and IC based on Model 13. The product term of OD and IC significantly influences EIL ($\beta$ = 0.307, p < 0.01). Thus, IC significantly moderates the

**Table 7**
Test results of moderating effect.

| Variables | ERL | | EIL | |
|---|---|---|---|---|
| | Model 11 | Model 12 | Model 13 | Model 14 |
| Size | 0.040 | 0.027 | -0.009 | -0.032 |
| Industry | 0.054 | 0.049 | 0.014 | 0.005 |
| Ownership | 0.016 | 0.018 | -0.025 | -0.020 |
| Age | 0.061 | 0.063 | 0.058 | 0.063 |
| OD | -0.420*** | -0.343*** | -0.439*** | -0.300*** |
| IC | 0.432*** | 0.482*** | 0.449*** | 0.540*** |
| OD×IC | | 0.170** | | 0.307*** |
| **Equation Indicators** | | | | |
| $R^2$ | 0.189 | 0.205 | 0.197 | 0.249 |
| Adj-$R^2$ | 0.174 | 0.187 | 0.182 | 0.232 |
| F | 12.357 | 11.664 | 13.011 | 14.991 |

*Notes: * P<0.1, ** P<0.05, *** P<0.01.*

association between OD and EIL, with a stronger innovation climate associated with a weaker negative relationship between OD and EIL. Therefore, Hypothesis 5 was verified.

## 5. Conclusions and Suggestions

*5.1. Research findings*

In today's complex and highly competitive business environment, academics and industry unanimously recognise that technology standards play a crucial role in building a competitive advantage for enterprises (Blind *et al*., 2021; De Vries and Veurink, 2017). As an advanced form of competition, strategic alliances enable enterprises to share technological achievements while reducing the costs and risks of standardisation (Jiang *et al*., 2022; Wakke *et al*., 2015). Nevertheless, the failure rate of TSAs remains high, and a considerable amount of scholarly work has been devoted to clearly understanding the structure of such alliances, their relationships, and their interactions to increase their effectiveness (Li *et al*., 2019; Wen *et al*., 2020). Accordingly, this study analyses the mechanism by which OD impacts TSAP, exploring the variability in TSAP from the perspective of subjective differences. More specifically, we utilised the ambidextrous analysis framework developed by March (1991) to clarify how organisational learning mediates the relationship between OD and TSAP and understand how subjective perceptions of IC moderate the relationship between OD and ambidextrous learning. We constructed a moderated mediation model and empirically tested it using longitudinal survey data from representatives of 325 enterprises in China's information and manufacturing industries. The empirical results thereby led to the following conclusions. (1) A larger OD is less conducive to achieving a high TSAP. (2) Ambidextrous learning partially mediates the impact of OD on TSAP. (3) IC negatively moderates the effect of OD on ambidextrous learning.

*5.2. Theoretical contributions*

The theoretical contributions of this study are as follows: First, although earlier studies discussed the impact of OD on the cooperation of enterprises and their strategic alliances (Monge *et al*., 1985; Chen and Lin, 2019; Martínez Ardila *et al*., 2020), its presence in TSAs has rarely been studied. This study specifically analysed the impact of knowledge and normative distance from the perspective of social network theory and validated the applicability of the theory proposed by Hsiao *et al*. (2017) in the context of TSAs. We find that OD negatively affects knowledge transfer between alliance enterprises. This enriches the literature on the factors affecting TSAP and improves our understanding of the heterogeneity of TSA processes. The second contribution of this study is that it shows how ambidextrous learning may affect the link between OD and alliance performance. Previous studies interpreted this relationship from the perspectives of resource integration, knowledge transfer, and organisational routines (Marrocu *et al*., 2013; Vande Vrande, 2013; Phelps, 2010), but they are not comprehensive. Simeoni *et al*. (2020) demonstrated that ERL and EIL enable the acquisition and utilisation of different types of epistemic resources. Our research further indicates that ambidextrous learning can alleviate the negative impact of OD on alliance performance, thereby explaining the paths linking OD, ambidextrous learning, and TSAP. The findings enrich the research on TSA from the perspectives of both organisational and ambidextrous learning, with each viewpoint forming the other. The final contribution of this study is, it confirms that in TSAs, positive IC can effectively alleviate the negative impact of OD on ambidextrous learning, thereby promoting TSAP. The conclusion defines the boundary conditions for the theories by Cummings *et al*. (2003) and expands the research on the role of IC proposed by Andersson *et al*. (2020) and Barba-Aragón *et al*. (2022).

Therefore, this study points to new ways to explore the relationship between organisational learning and alliance performance. It also provides a theoretical basis for enterprises to strengthen organisational learning, develop more effective TSAs, and enhance their competitive advantages.

*5.3. Managerial implications*

Amidst the increasingly fierce competition for technology standards, the conclusions of this study have specific implications for current practices. First, a coordinated alliance must be established. When obtaining a competitive advantage in standards through TSAs, enterprises should accommodate the knowledge and cultural backgrounds of their partners, actively coordinate relationships between them, and form unified goals for the alliance. Our study shows that differences in the knowledge structure, organisational culture, skills, and institutional customs of members may negatively impact the alliance's performance. Therefore, it is crucial to actively coordinate the standardised behaviours of alliance partners, establish deep mutual trust and beneficial relationships, and avoid opportunistic behaviours and conflicts of interest. Thus, the alliance's overall strength improves, R&D is stimulated, and alliance standards are promoted.

The second implication is the strengthening of diversified organisational learning. Improving TSAP requires members to collaborate, and ambidextrous learning occurs when members cooperate to exchange knowledge and information resources. Thus, enterprises should actively strengthen ERL to expand their networks of relationships and thereby share responsibility for sharing risks and resources. Additionally, enhancing EIL will nurture communication, reduce the distance between partner organisations in alliances, negate potential risks, and improve the alliance's overall performance.

The final implication is that enterprises should focus on improving their IC. When standardising technologies, individual members' perceptions of support for innovation strongly influence a company's willingness to participate in organisational learning. Creating strong IC helps employees actively explore knowledge from new domains, thereby promoting the reorganisation and reconstruction of knowledge resources and alleviating the uncertainty caused by organisational differences. Similarly, a positive IC encourages trust and cooperation among alliance members via timely communication and exchange of ideas. These features help enterprises acquire knowledge in related fields, such as technology and management. A powerful IC indicates the initiative of enterprise management. It also helps strengthen organisational learning and overall performance.

*5.4. Limitations and suggestions for future research*

There are three principal limitations of this study and corresponding avenues for future research. First, we sought to obtain more rigorous research conclusions by selecting industries that are particularly involved in TSAs. However, the specific characteristics of these industries limit, to some extent, the universality of our conclusions. Subsequent research should therefore study TSAs in additional industries to uncover local variations while obtaining generalizable conclusions. Second, the sole use of questionnaires to measure the constructs runs the risk of biased performance measurement if other methods are not used. Therefore, future research into TSAs should match the questionnaires to the available second-hand data. Third, the findings were all obtained at the same time, without distinguishing between the three stages of developing, implementing, and promoting standardised technology. Future research should therefore be conducted at all of these stages, each of which can serve as a control variable to observe how OD impacts alliance performance.

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