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Research on network capacity, absorptive capacity and service innovation performance of technology business incubators—based on PLS-SEM and fsQCA methods

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Introduction: In the new economic normal, technology incubators are an important support to achieve the growth of strategic emerging enterprises. On the basis of resource based theory, organizational learning theory, inter-organizational relationship theory, and network capability theory, this study constructs a theoretical framework and hypotheses of the impact of network capability within the "resource-capability-relationship" perspective, absorptive capacity on service innovation performance of technology business incubators.

Methods: This study uses 234 Chinese incubators in the incubator network as samples and applies partial least squares structural equation modeling (PLS-SEM) and fuzzy-set qualitative comparative analysis (fsQCA) to explore the questions mentioned above.

Results: The results verify the relationship between network capacity, absorptive capacity, and service innovation performance. Furthermore, the results yield four paths that lead to high service innovation performance, such as "network capability orientation" and "high absorption orientation", which are different combinations of network capacity and absorptive capacity.

Discussion: The research results are important for improving the innovation performance of technology incubator services and ensuring the stable and effective operation of incubated enterprises.

KEYWORDS

network capability, absorptive capacity, technology business incubators, service innovation performance, fsQCA, PLS-SEM

1 Introduction

Technology business incubators have become an institutionalized part of innovation-driven policies worldwide to promote innovation, entrepreneurship, and economic growth (Mian et al., 2016). Technology business incubator, as an important carrier of industry and enterprise innovation capability improvement and innovation system construction in the new normal situation of "Mass Entrepreneurship and innovation" (Fu et al., 2021). It has created excellent professional service platforms such as resource knowledge and technology for China's small, medium and micro technology incubators, promoting the incubators to rapidly grow into gazelle enterprises, accelerating the transformation and innovation of traditional industrial structure (Hausberg and Korreck, 2021). By the end of 2019, there were more than 7,000 technology business incubators worldwide, most of which are supported by local and central governments Li. (2020). Traditional technology business incubators provide incubators with the resources and services necessary for business operations (infrastructure management services and technical know-how, *etc.*). At the same time, it helps incubators achieve resource integration and supports incubators to survive and grow in the fierce market competition (Tang et al., 2021). The upgrade and restructuring of technology business incubators through service innovation is the best way and most feasible path for incubators to gain heterogeneity, differentiation, and sustainable competitiveness, which is expected to break through the traditional "nanny" service model, achieve leapfrog development, enhance the service capacity of the incubator and accelerate the growth of incubators (Yuan et al., 2022).

Based on social network theory, Granovetter. (2008) argues that all economic activities of incubators are embedded in social networks of relationships. The study pointed out that an external social network of relationships is an important vehicle for incubators to obtain scarce resources such as knowledge and to carry out innovative activities (Adler and Kwon, 2002). It was found that through incubator networks, incubators gained more opportunities for business collaboration and gained more access to scarce resources, which in turn improved innovation performance (Bruneel et al., 2012; Ayatse et al., 2017). Thus, it is clear that how to improve the innovation performance of incubators in incubator networks is an important issue facing current research. Lavie. (2007) pointed out that firms with similar network partners have a large gap in the innovation performance they obtain, which is mainly due to the differences in the network capabilities of firms. However, based on the perspective of incubators in incubator networks, few scholars have further explored the mechanisms through which network capabilities affect innovation performance (Hoffmann, 2007; Lavie, 2007), resulting in the role of network capabilities of incubators in incubator networks remains full of unknowns.

Based on resource-based theory, Barne. (1991) argues that resource acquisition and development help incubators enhance their competitive advantage. It was found that external resources acquired through social networks can effectively contribute to the competitive advantage of incubators only if they form a complementary effect with the internal resources of incubators (Lin et al., 2012; Wu et al., 2021). However, scholars studying the internal capabilities of incubators hold a different view, arguing that the network theory school overemphasizes the role of external ties in influencing the innovation performance of incubators while ignoring the central role played by absorptive capabilities. Further research has found that incubators differ in their absorptive capacity and that it is these differences in the capacity that leads to differences in the innovation performance of incubators (Miranda et al., 2022). Zahra and George (2002) suggest that firms with higher absorptive capacity have better innovation performance and will have a much better chance of winning in the competitive market. However, based on the perspective of incubators in incubator networks, there is a paucity of scholarly research on how network capabilities affect innovation performance through absorptive capacity. Therefore, this study aims to answer the following questions:

- How does network capacity affect innovation performance?
- How does absorptive capacity affect innovation performance?
- What is the relationship between network capacity and absorptive capacity?
- How do network capability and absorptive capacity jointly contribute to innovation performance?

In view of the special role of technology business incubators in the process of innovation, entrepreneurship, and industrial transformation and upgrading, this study constructed a theoretical analysis framework of "resource-capacity-relationship" based on strategic management theory, and resource-based theory, network capability theory, and absorptive capacity theory. Taking 234 Chinese incubators as the research object, this study discusses the impact of the relationship between network capability and service innovation performance of technology business incubators under the coupling of "resource-capability-relationship" and empirically tests the mediating role of absorptive capacity. In this study, fuzzy set qualitative comparative analysis (fsQCA) and structural equation modeling (PLS-SEM) was used for data analysis. It was found that network resource patching ability, network cross-organization learning ability, network relationship interaction ability, potential absorptive capacity, and actual absorptive capacity impact service innovation performance. In addition, absorptive capacity mediates the relationship between network capability and service innovation performance. This study helps to deepen the understanding of incubators to realize network capability and service innovation performance through absorptive capacity, and has profound theoretical and practical value.

The rest of this paper is organized as follows: Section 2 provides the research hypothesis and theoretical framework construction. Section 3 describes the data and method. Section 4 presents the result and stability checks. Section 5, we present the discussion of the findings and research implications. Section 6, we present conclusions. Finally, in Section 7, we set forth the limitation of the research and the direction of the next research.

2 Theoretical analysis and hypothesis

2.1 Theoretical framework of network capabilities in the framework of "resource-capability-relationship"

The dynamic and complex cooperative relationships of service innovation networks require technology business incubators to use their network capabilities for reasonable management and control to achieve the strategic goals of service innovation (Franco et al., 2018; Chereau and Meschi, 2021; Cepeda-Carrion et al., 2022). Since Ritter et al. (2004) proposed the concept of network capability, many scholars have conducted extensive research on the structure of network capability dimensions (Ávila, 2022), the influence mechanism between network capability and other weighting factors (Yu and Chong, 2005) and the mechanism of network capability operation in different contexts from multiple perspectives and levels (Al-Mubaraki and Busler, 2017), but there is a lack of integration research from a multi-theoretical coupling perspective (Branstad and Saetre, 2016). This study deconstructs network capabilities from three aspects: Resource-based theory, capability theory, and inter-organizational relationship theory. The resource-based theory argues that heterogeneous resources are the root cause for firms to gain competitive advantage (Barney, 1991). Capability theory argues that value arises from a firm's ability to allocate heterogeneous resources (Grant, 1991). Inter-organizational relationship theory suggests that "relational transactions" can spontaneously interact with each other from disorderly and chaotic external relationships, effectively integrating the absorbing capabilities distributed in innovation network relationships and creating new capabilities (Oliver and Ebers, 1998). In the innovation-driven context, the innovation of technology business incubator services is essentially dependent on the incubator's ability to effectively allocate and coordinate the heterogeneous resources, knowledge, and relational rents in the external innovation network with reasonable network resources, and then realize internal and external knowledge exchange, integration and engineering. This paper integrates resource-based theory, dynamic capability theory, and inter-organizational relationship theory, and proposes a theoretical analysis framework of "resource patchwork, absorption capability, and relationship interaction" from the perspective of external network relationship, referred to as "resource, capability, and relationship" theoretical framework.

Network resource patching ability refers to the incubator's ability to fully utilize and develop internal and external resources, and to reorganize and absorb existing resources (Vicentin et al., 2021). The network resource patchwork ability of science and technology business incubators not only creates the environment but also co-evolves with the external environment. It can help incubators identify the form, type, and substitution of resources and carry out resource evaluation, providing strong resource base support for the growth and development of incubators, and then promoting the service innovation of science and technology business incubators. Network cross-organization learning ability refers to the technology business incubators to provide the incubated enterprises innovation learning, and the guest room and third-party professional service (such as technical support, talent recruitment, talent training, production management, marketing management, business consulting, *etc.*) the ability of to the incubated enterprises rapidly correct organizational behavior and change the backward organizational routines, graduated with an acceleration in the incubated enterprises and growth (Zhan and Xie, 2022). It aims to realize the innovation of technology business incubator service. Network relationship interaction capability refers to the ability of technology business incubators to construct an external value relationship network, which aims to build a high-quality network relationship platform for incubators, accelerate the formation of an "active knowledge field" between incubators themselves and network relationship partners, and promote incubators to quickly embed value relationship network. Better access to external heterogeneous resources, specific knowledge, skills, services, *etc.*, to accelerate the development of incubated enterprises.

2.1.1 Network resource patching ability and service innovation performance

If incubators lack network resource patching ability, it will be difficult to identify innovative activities and opportunities in the incubator network. Bøllingtoft and Ulhøi. (2005) proposed that network resource patching ability is the basic ability of incubators to deal with network changes. Through this ability, incubators can better understand the network environment. Teece. (2007) found that network resource patching ability helps incubators to discover the value and potential of partners in the incubator network from a strategic level, and then grasp the evolution trend and development direction of the incubator network (Theodorakopoulos et al., 2014). Therefore, incubators with strong network resource patching ability can better perceive the strategic opportunities in the incubator network (van Weele et al., 2020), so that the services innovation performance of the incubator can be effectively improved. Based on this, the following hypothesis is proposed.

Hypothesis 1. (H1): Network resource patching ability positively affects service innovation performance.

2.1.2 Network resource patching ability and service innovation performance

Liebeskind et al. (1996) argued that network cross-organization learning ability can help incubators complete a relationship network with a sufficient number and type of partners. Oliver and Ebers. (1998) found that enterprises can effectively manage the linkage density of incubators and network partners through network cross-organization learning ability. Ndubisi et al. (2020) suggested that the network cross-organization learning ability of incubators positively influences firms' service innovation. Based on this, the following hypothesis is proposed.

Hypothesis 2. (H2): Network cross-organization learning ability positively affects service innovation performance.

2.1.3 Network relationship interaction capability and service innovation performance

Tsai. (2001) suggests that network relationship interaction capability facilitates knowledge transfer between incubators and partners, thus promoting innovation. Ford. (1980) found that the deepening of partnership helps to complete long-term technology project collaboration and gives firms a competitive advantage. Dhanaraj and Parkhe. (2006) found that stable relationships between partners help incubators' knowledge acquisition and innovation performance. Based on this, the following hypothesis is proposed.

Hypothesis 3. (H3): Network relationship interaction capability positively affects service innovation performance.

2.2 Network capability and absorptive capacity

The concept of absorptive capacity first appeared in a paper published by Cohen and Levinthal. (1990). Absorptive capacity is defined as an enterprise's ability to identify, evaluate and absorb external new knowledge and then apply it in commercial output.

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Zahra and George (2002) defined absorptive capacity as the dynamic ability of enterprises to create and apply knowledge to obtain and maintain competitive advantages, which has been recognized by most scholars. Lane et al. (2006) proposed that absorptive capacity is the ability of enterprises to apply external new knowledge through exploration, transformation, and development learning processes. Based on the research of Zahra and George (2002), this paper summarizes absorptive capacity as the dynamic ability of enterprises to acquire, digest and transform external new knowledge and technology, and integrate it into commercial output. In this paper, absorptive capacity is divided into two dimensions: potential absorptive capacity (knowledge acquisition and digestion) and actual absorptive capacity (knowledge conversion and application). The following will study the influence on the two dimensions of absorptive capacity from the three dimensions of network capacity.

2.2.1 Network relationship interaction capability and service innovation performance

As a strategic network capability, network resource patchwork capability focuses on the strategic thinking of incubators' networks (Tavoletti, 2013). Dyer and Nobeoka. (2000) found that the ability to assemble network resources can further clarify the identity of incubators in the enterprise network, to obtain in-depth information and knowledge, thus promoting knowledge acquisition. Mohr and Sengupta. (2002) proposed that the ability to put together network resources can help incubators analyze the knowledge they need from a strategic perspective, enhance learning intention and motivation, and thus promote the digestion and application of knowledge. Based on this, the following hypothesis is proposed.

Hypothesis 4a. (H4a): Network resource patchwork capability positively affects potential absorptive capacity.

Hypothesis 4b. (H4b): Network resource patchwork capability positively affects actual absorptive capacity.

2.2.2 Network resource patching ability and absorptive capacity

As the network capability at the structural level, network cross-organization learning ability can help incubators establish a relationship network with a sufficient number of partners and diverse types (Mohr and Sengupta, 2002). Through the network cross-organization learning ability, incubated enterprises can select key partners and establish direct connections with them to acquire more valuable knowledge, thus promoting the acquisition and digestion of knowledge. Dyer and Singh. (1998) found that network cross-organization learning ability helps incubated enterprises to establish a network of relationships, and promotes joint learning and knowledge exchange among partners, thus promoting knowledge learning and transfer. Kohtamäki and Bourlakis. (2012) proposed that the network cross-organization learning ability builds a platform for mutual learning between incubators and partners, significantly improves the dynamic ability of network organizations, and then promotes knowledge learning and application. Based on this, the following hypothesis is proposed.

Hypothesis 5a. (H5a): Network cross-organization learning ability positively affects potential absorptive capacity.

Hypothesis 5b. (H5b): Network cross-organization learning ability positively affects actual absorptive capacity.

2.2.3 Network relationship interaction capability and absorptive capacity

As network capability at the relationship level, network relationship interaction capability can assist incubated enterprises to deal with, coordinating, controlling, and deepening the connection with partners (Mu and Di Benedetto, 2012). Ebers and Maurer. (2014) first proposed the concept of "relational absorptive capacity", which integrates the connotation of network relationship interaction capacity and absorptive capacity. "Relational absorptive capacity" indicates that the absorptive capacity of an enterprise must be placed in the cooperative relationship of network partners to effectively play the role of network relationship interaction capacity. That is, network interaction ability has a significant impact on absorptive capacity. Yli-Renko et al. (2002) found that for incubators and partners, a high-level network relationship can not only guarantee the efficiency of information acquisition but also improve the quality of information exchange, thus enhancing the potential absorption capacity. Uzzi. (1997) pointed out that the network interaction ability of incubators contributes to the communication and interaction between network partners, thus promoting the transformation and application of external knowledge of incubators and enhancing their actual absorption capacity. Based on this, the following hypothesis is proposed.

Hypothesis 6a. (H6a): Network relationship interaction capability positively affects potential absorptive capacity.

Hypothesis 6b. (H6b): Network relationship interaction capability positively affects actual absorptive capacity.

2.3 Absorptive capacity and service innovation performance

Potential absorptive capacity consists of knowledge acquisition capacity and knowledge digestion capacity (Zahra and George, 2002). Stock et al. (2001) proposed that knowledge acquisition ability can enable enterprises to have a deeper understanding of customers' needs and further promote enterprises to develop new products in a more targeted manner. Dyer and Singh. (1998) found that knowledge acquisition ability, on the one hand, promoted the reduction of product defects in enterprises; On the other hand, shorten the product development cycle effectively and improve the innovation performance. Atuahene-Gima. (2003). believes that knowledge digestion ability can help enterprises in the following two aspects: first, it can help enterprises to speed up problem-solving in new product development; The second is to helps enterprises update the knowledge base in time so that the repetitive work can be effectively avoided. To sum up, the potential absorptive capacity can improve the service innovation performance of enterprises. Actual absorptive capacity consists of knowledge conversion capacity and knowledge application capacity. Todorova and Durisin. (2007) believe that knowledge transformation ability can not only help enterprises restructure their cognitive structure, but also help enterprises get rid of their dependence on knowledge path, to further enhance their competitive advantages. Neergaard. (2005) proposed that knowledge

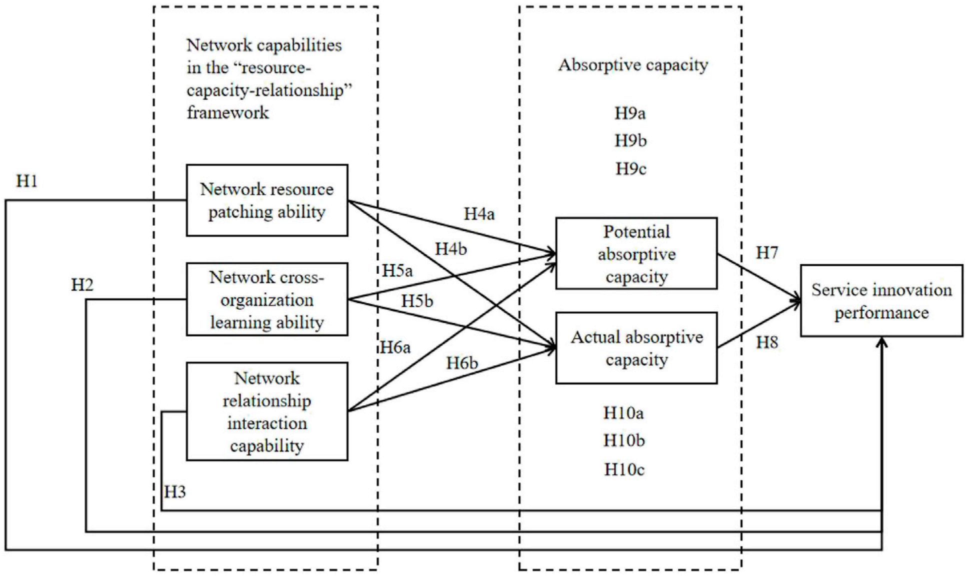

FIGURE 1
Research model.

application is indispensable in the process of transforming resources and information into new products or new ideas for enterprises. Lichtenthaler. (2009) found in his study that to cope with changes in the external environment, enterprises can develop new products only by continuously enhancing their knowledge conversion ability and knowledge application ability. To sum up, the actual absorptive capacity can improve the service innovation performance of enterprises. Based on this, the following hypothesis is proposed.

Hypothesis 7. (H7): Potential absorptive capacity positively affects service innovation performance.

Hypothesis 8. (H8): Actual absorptive capacity positively affects service innovation performance.

2.4 The mediating role of absorptive capacity

This paper constructs the influence mechanism framework of network capability, absorptive capacity, and service innovation performance of technology business incubators under the framework of "resource-capability-relationship", as shown in Figure 1.

3 Data and method

3.1 Data collection and variable measurement

This paper focuses on the influence mechanism between network capacity, absorptive capacity, and service innovation performance, uses the conceptual model proposed by multiple observation variables to measure, draws on mature scales to design and compile questionnaires, and draws on the on-the-job engineering master, MBA, EMBA, *etc.* A total of 65 students took the pre-test, and based on the results of the pre-test, the items of the questionnaire were perfected and revised to form the final questionnaire. The subjects of this survey are technology business incubator executives (chairman, general manager, and senior management), executives of incubating companies, and core members of the innovation team. The research area involves national technology business incubators such as Xi'an High-tech Industrial Park, Shaanxi Province, Qinchuangyuan Innovation Drive Platform of Xixian New District, Shaanxi Province, and University Science and Technology Industrial Park, Shaanxi Province. From June to December 2021, the subject group 6 in-depth interviews were conducted with the research objects and questionnaires were distributed.

The foundations of the study design are in the literature review section. This study utilizes and adjusts scales from earlier studies in which the items and responses were measured range is from "very dissatisfied" to "very satisfied" corresponding to the numbers "1" to "7". Table 1 lists the variables and their measurement methods used in this study. At the same time, a questionnaire survey was conducted on the target enterprises by E-mail. A total of 500 questionnaires were issued, 350 were finally recovered, 116 invalid questionnaires were removed, and 234 valid questionnaires were finally obtained, with an effective rate of 46.8%. The descriptive statistics of the sample are as follows: In terms of gender, males and females accounted for 65.81% and 34.19%; From the scale of the surveyed enterprises, 10% have more than 500 employees, 20% have 301–500 employees, 25% have 151–300 employees, 25% have 50–150 employees, and 20% have less than 50 employees. In terms of positions surveyed, senior executives account for 5.98%, department heads for 36.32%, project managers for 42.73%, and innovation team members for 9.97%.

TABLE 1 Survey variables and measures.

Variable	Measurement item	Sources
Network resource patching ability	Our enterprise can use the resources of the incubation network to develop solutions to new challenges such as the innovation needs of incubators	Senyard et al. (2009)
	Our enterprise can cope with new challenges through the integration and utilization of existing resources and incubation network resources	
	Our enterprise can effectively deal with the incubation problem by integrating and utilizing existing resources that were originally used for other aspects	
Network cross-organization learning ability	Our enterprise can quickly and accurately gain valuable knowledge and experience from the incubation network	Liebeskind et al. (1996)
	Our enterprise is good at coming up with creative improvement measures and solutions	
	Our enterprise can effectively build incubator-wide shared knowledge, experience methods, systems, and platforms	
	Our enterprise often reflects on the past work and draws out the corresponding experience and lessons	
Network relationship interaction capability	Our enterprise is good at identifying intermediaries who hold a lot of related resources	Ritter and Gemünden (2003)
	Our enterprise has set up a functional department dedicated to handling external cooperation relations	
	Our enterprise regularly communicates and interacts with external incubation network organizations in various forms	
	Our enterprise continuously builds, deepens, and improves relationships with external incubation network organizations based on our experience	
Potential absorptive capacity	Our enterprise can pay attention to and collect new technologies and knowledge emerging in the industry promptly	Ritter et al. (2004)
	Our enterprise can accurately assess the value of new technologies and knowledge	
	Our enterprise is in constant contact with the outside world to acquire new technologies and knowledge	
	Our enterprise can quickly analyze and understand the new technologies and knowledge that has been acquired	
	Our enterprise can learn new technologies and knowledge acquired at a faster pace	
Actual absorptive capacity	Our enterprise regularly discusses market trends and new product development matters	Ritter et al. (2004)
	Our enterprise can effectively integrate its existing relevant knowledge and technology with the new technology and knowledge after digestion	
	Our enterprise is better able to use new knowledge to develop new markets	
	Our enterprise can use the new knowledge to improve existing profitability models or launch new business models	
Service innovation performance	New services to meet the dynamic needs of incubators	Voss and Voss (2000), Monica Hu et al. (2009)
	The quality and level of new services exceeded the expectations of incubators	
	incubators are satisfied with the quality of new services provided by the incubator	
	The incubators are satisfied with the new service implementation and cooperation	
	Service innovation has led to a greater increase in the incubation capacity of the incubator	

3.2 Method research

Compared with traditional statistical methods, the qualitative comparative analysis (QCA) method is more suitable for this study. The reasons are as follows: First, different from the traditional regression method which focuses on exploring the "net effect" of a variable, QCA is based on the "configuration theory" and makes a reasonable explanation of the complex causes of the outcome variables by dealing with the multi-factor linkage relationship. Second, unlike the large sample data requirements of traditional statistical methods, QCA only needs small sample data (at least a dozen samples) to establish a causal relationship between the antecedent variables and the outcome variables. Thirdly, compared with the traditional regression method which can only

TABLE 2 Reliability and validity.

Variable	Item	Convergent validity			Cronbach's alpha	Multicollinearity
		Cross loadings	Composite reliability	AVE		VIF
Network resource patching ability (NRPA)	NRPA1	0.931	0.942	0.843	0.907	3.377
	NRPA2	0.942				3.774
	NRPA3	0.881				2.473
Network cross-organization learning ability (NCOLA)	NCOLA1	0.817	0.882	0.651	0.821	1.728
	NCOLA2	0.823				1.811
	NCOLA3	0.795				1.691
	NCOLA4	0.792				1.664
Network relationship interaction capability (NRIC)	NRIC1	0.850	0.915	0.729	0.875	2.110
	NRIC2	0.794				1.693
	NRIC3	0.895				3.719
	NRIC4	0.872				3.268
Potential absorptive capacity (PAC)	PAC1	0.848	0.926	0.717	0.900	3.719
	PAC2	0.883				4.476
	PAC3	0.892				3.397
	PAC4	0.881				2.819
	PAC5	0.718				1.556
Actual absorptive capacity (AAC)	AAC1	0.837	0.904	0.702	0.858	2.162
	AAC2	0.868				2.440
	AAC3	0.849				2.096
	AAC4	0.796				1.686
Service innovation performance (SIP)	SIP1	0.879	0.950	0.792	0.934	4.269
	SIP2	0.884				4.587
	SIP3	0.900				3.610
	SIP4	0.913				4.746
	SIP5	0.873				3.625

deal with the symmetric relationship between variables, QCA allows and can deal with asymmetric causality well.

According to the variable type, QCA is divided into three operation methods: fuzzy set (fsQCA), crisp-set qualitative comparative analysis (csQCA) and multi-value qualitative comparative analysis (mvQCA). Among them, csQCA and mvQCA are suitable for dealing with binary categorical variables and multi-category variables respectively. fsQCA deals with partial membership problems and degree changes by using the membership degree between 0 and 1 to represent the possibility of causal conditions. The variables involved in this study are mostly continuous variables, and there are problems of partial membership and degree changes. Therefore, fsQCA is used to more fully observe the subtle effects of changes in variable combinations under different conditions (Ragin, 2008).

In this paper, PLS-SEM (Hair et al., 2019) and fsQCA (Fiss, 2011) are selected to conduct causal and path analysis of network capacity and absorptive capacity on service innovation performance (Schlittgen et al., 2016). This study employs partial least squares structural equation modeling (PLS-SEM). Like most theoretical exploratory studies, the sample size of this study is relatively small, and the PLS-SEM model is suitable for the empirical analysis of this paper because it applies a non-parametric inference method for exploratory research characteristics (Woodside, 2016), and the sample data do not need to satisfy the normal distribution (Ringle et al., 2012). In this paper, the PLS-SEM model was constructed using SmartPLS3.0 software (Rigdon, 2012). This study employs fsQCA to address H9a-H9c and H10a-H10c. Seny Kan et al. (2016) argue that fsQCA is a novel way to access knowledge on organizations and management issues.

TABLE 3 Discriminant validity—Fornell-Larcker Criterion and Heterotrait - Monotrait Ratio.

	Mean	S.D.	1	2	3	4	5	6
1. Actual absorptive capacity	4.72	1.11	**0.838**	0.811	0.352	0.486	0.607	0.716
2. Network cross-organization learning ability	4.9	1.15	0.681**	**0.807**	0.345	0.438	0.634	0.694
3. Network relationship interaction capability	5.43	1.05	0.307**	0.294**	**0.854**	0.233	0.384	0.443
4. Network resource patching ability	3.81	1.55	0.429**	0.376**	0.21**	**0.918**	0.417	0.567
5. Potential absorptive capacity	5.17	1.17	0.539**	0.548**	0.339**	0.387**	**0.847**	0.634
6. Service innovation performance	5.04	1.06	0.644**	0.611**	0.402**	0.527**	0.589**	**0.89**

Note: Significant level:$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$, Bold diagonal entries are square root of AVEs, Heterotrait-Montrait ratios (HTMT) (Underlined) are below 0.85.

TABLE 4 Significant testing results of the structural model path coefficients.

	Path coefficient	t-value	*p*-value	95% BCa confidence interval	Conclusion
AAC - > SIP	0.257	2.941	0.003	(0.084,0.425)	H8 supported
NCOLA - > AAC	0.581	9.599	0.000	(0.454,0.689)	H5b supported
NCOLA - > PAC	0.426	6.263	0.000	(0.298,0.561)	H5a supported
NCOLA - > SIP	0.192	2.147	0.032	(0.017,0.365)	H2 supported
NRIC - > AAC	0.064	1.87	0.061	(0.015,0.196)	H6b not supported
NRIC - > PAC	0.174	2.649	0.008	(0.045,0.299)	H6a supported
NRIC - > SIP	0.148	2.608	0.009	(0.034,0.258)	H3 supported
NRPA - > AAC	0.191	3.383	0.001	(0.086,0.305)	H4b supported
NRPA - > PAC	0.191	3.036	0.002	(0.068,0.314)	H4a supported
NRPA - > SIP	0.235	4.026	0.000	(0.114,0.343)	H1 supported
PAC - > SIP	0.204	2.927	0.003	(0.061,0.333)	H7 supported

SRMR composite model = 0.067.
$R^2_{PAC} = 0.366$; $Q^2_{PAC} = 0.252$.
$R^2_{AAC} = 0.507$; $Q^2_{AAC} = 0.347$.
$R^2_{SIP} = 0.586$; $Q^2_{SIP} = 0.453$.
5000 bootstrap samples.

4 Result

4.1 Evaluation of measurement model

Using SmartPLS 3.0 for reliability analysis (see Table 2), all construct factor loadings took values ranging from 0.718 to 0.942 (Fornell and Larcker, 1981), all reaching a significance level of $p < 0.001$, Cronbach's alpha took values ranging from 0.821 to 0.934, and composite reliability (CR) took values ranging from 0.882 to 0.950. The internal consistency and combined reliability of the variables were high. The average variance extracted variance (AVE) of all the constructs was greater than the threshold of 0.5, indicating good convergent validity of the model; the square root of AVE of all the variables was greater than the correlation coefficients of the constructs with other constructs, indicating good discriminant validity of the model (see Table 3). The Heterotrait-Monotrait ratio was used to assess the discriminant validity, which is more sensitive for dealing with the validity of variance-based structural equations, and it was found that the ratios were all below the threshold of 0.85 (see Table 3). In summary, the measurement model met the basic requirements of reliability and validity.

4.2 Evaluation of measurement model

The predictive power of the model in this study was evaluated by the internal model explanatory efficacy using R^2 (multiple coefficients of determination), where a higher value of R^2 indicates that the measured variables explain the latent variables better. In this study, AAC explained the model to the extent of 0.507, PAC explained the model to the extent of 0.366, and SIP explained the model to the extent of 0.586 (see Table 4). In general, R^2 is weak between 0.25 and 0.5 and moderate between 0.5 and 0.75 (Afonso et al., 2018). Similarly, all VIF values are below the common cutoff threshold of 5 (Hair et al., 2012). Similarly, results from blindfolding with an omission distance of 7 yield Q^2 values well above zero (Table 4). In summary, the explanatory power of the model in this study is generally in line with the requirements.

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TABLE 5 Calibration positioning points of case variables.

Variables		Locating point		
		Full membership	Crossover point	Full non-membership
Outcome variables	SIP	7	5	3.71
	NCOLA	6.5	5	3.5
	AAC	6.25	4.75	3.25
Conditional variables	NRPA	6	4	1.33
	PAC	7	5	3.89
	NRIC	7	5.5	4

4.3 Fuzzy set qualitative comparative analysis (fsQCA) approach

QCA is based on set theory and holistic perspective (Fiss, 2011) and is able to explain the composition of antecedents that lead or do not lead to a certain outcome. Based on the research model, fsQCA is used to analyze the complex antecedents of service innovation performance of technology incubators by taking service innovation performance as the outcome variable, as follows: firstly, the raw data are calibrated to obtain fuzzy affiliation scores; secondly, all antecedent variables are tested for necessity conditions; finally, the combination of sufficient conditions is determined using truth table analysis (Rihoux and Ragin, 2009).

4.3.1 Calibration procedure

"Calibration is the process of assigning an ensemble affiliation score to a case" (Fiss, 2011). Ragin. (2008) defines fuzzy sets as fully affiliated, intersection, and fully unaffiliated to establish the association of variables with fuzzy sets. It is centered on combining multiple aspects to select 3 reasonable anchors and explanations for the variables, typically 95% high-quantile, median (50%), and 5% low-quantile of the sample data.

The results and calibration information for each conditional variable are listed in Table 5.

4.3.2 Analysis of necessary conditions

The QCA method includes two types of analyses, necessity analysis of conditions and group state analysis of conditions, which are performed separately and necessity analysis is performed prior to group state analysis of conditions. The necessity test identifies the extent to which a single factor or variable influences the results. The QCA method is case-oriented, and the results of the QCA path analysis may be erroneous if a single variable plays a decisive role in the results. Therefore, in the early studies of the QCA method of necessity analysis, scholars had different views on whether the necessary conditions should be retained or not, and when the necessary variables are not identified and the group analysis is performed directly, there is a risk that the necessary conditions will be eliminated by the minimization process. The necessity test usually requires a minimum value of 0.9 for consistency, above which the variable is considered necessary for the outcome to occur, and its corresponding coverage is an important indicator of the empirical relevance of the necessity condition in the necessity analysis (see Table 6). Following the recommendations from Ragin. (2008) and Fiss. (2011), this study sets consistency and PRI consistency thresholds to 0.8 and 0.5, respectively, thus identifying the solutions that lead to high service innovation performance.

TABLE 6 Analysis of necessary conditions.

Conditional variable	High-level SIP	
	Consistency	Coverage
NCOLA	0.789263	0.810349
~ NCOLA	0.616619	0.555546
AAC	0.813991	0.801877
~ AAC	0.580062	0.542719
NRPA	0.761614	0.749419
~ NRPA	0.565902	0.530049
PAC	0.851667	0.763229
~ PAC	0.546508	0.564550
NRIC	0.748524	0.719329
~ NRIC	0.632815	0.606535

4.3.3 FsQCA solution

The results of high service innovation performance were calculated by fsQCA3.0, and since the intermediate solution is more likely to reflect the actual results, the intermediate solution was used for the analysis (Rihoux and Ragin, 2009), resulting in four antecedent condition groupings of high service innovation performance (see Table 7). the consistency values of the four high service innovation performance groupings were 0.924, 0.925, 0.910, and 0.940, with an overall consistency of 0.881. This indicates that the four histories are sufficient conditions for achieving high service innovation performance when the majority of cases are satisfied; the overall coverage is 0.766, thus explaining 76.6% of high service innovation performance. From the results, fsQCA effectively identifies the four histories of high service innovation performance and has strong explanatory power, which validates the antecedent construct of high service

TABLE 7 Configurations of high service innovation performance.

Conditional configuration	Path			
	Network capability orientation		Absorptive capacity orientation	
	Configuration 1	Configuration 2	Configuration 3	Configuration 4
NCOLA	●	●	●	
AAC	●		●	●
NRPA	●	●		●
PAC		●	●	●
NRIC				⊗
Raw coverage	0.599223	0.600318	0.644775	0.424682
Unique coverage	0.0488294	0.0499247	0.0943816	0.0221214
Consistency	0.923954	0.925465	0.910224	0.939979
Solution coverage	0.765651			
Solution consistency	0.880854			

Note: The black circles (●) denote the presence of a condition, whereas the crossed-out circles (⊗) indicate the absence of one (Ragin, 2008). Core elements of a configuration are marked with large circles (prime implicants), peripheral elements with small ones and blank spaces are an indication of a "don't care" situation in which the causal condition may be either present or absent (Mikalef et al., 2015).

innovation performance due to the asymmetric characteristics of the histories.

Configuration 1 and configuration 2 are network capability orientation configurations. Configuration 1: Network cross-organization learning ability, network resource patching ability, and actual absorptive capacity are the core conditions. Configuration 2: Network cross-organization learning ability, network resource patching ability, and potential absorptive capacity are the core conditions. This sort of configuration shows that in the "network capability orientation" incubator network, the two dimensions of incubators' network competence are the key to achieving high service innovation performance. That is, if the network capability of the incubator network is based on network cross-organization learning ability and network resource patching ability as the main index, then the incubators should also pay attention to the cultivation of the network capability in terms of learning, coordination, and resources. This highlights the truth that "It takes a good blacksmith to make good steel."

Regarding core conditions, configuration 3 and configuration 4 embody the feature of "high absorption". They indicate that when potential absorptive capacity and actual absorptive capacity play a prominent role in the incubator network, the incubators' network-network resource patching ability and network cross-organization learning ability are the key to achieving high service innovation performance. It further shows that when incubators value "absorptive capacity", orchestrating resources (network resource patching ability) and maintaining cooperative relations (network cross-organization learning ability) are the necessary competencies for incubators to achieve high service innovation performance. Specifically, configuration 3 shows that if potential absorptive capacity and actual absorptive capacity are important network capacity elements, incubators need strong network cross-organization learning ability to make up for it. Conversely, as shown in configuration 4, if network relationship interaction capability is not important, network resource patching ability should become the important factor of the network capacity to ensure the realization of high service innovation performance.

This study concludes on the asymmetrical nature of the causal relationships leading to high service innovation performance. Overall, the fsQCA results provided in Table 7 support H9a, H9b, H9c, H10a, and H10b, and not support H10c. The results of fsQCA once again support the results in PLS-SEM.

4.4 Robustness test

We used standard methods to conduct a robust analysis of QCA results. The commonly used methods are: Adjust the calibration threshold, change the consistency threshold, add or delete the shell, change the frequency threshold, and add other conditions. Method 1: Referring to the practice of Fiss, the robustness test is carried out by adjusting the crossing point of calibration. Specifically, the crossing point is adjusted from 0.5 to 0.55. The number of configurations and the neutral permutations with the same core conditions but different edge conditions all changed slightly, but the changes were not enough to support meaningful and completely different substantive interpretation method 2. Referring to the set relation and quasi-sum difference of configurations proposed by Schneider and Wagemann. (2012) as the judging criteria, this paper reduced the consistency threshold from 0.8 to 0.75 and found that the research configurations were still supported. Therefore, the research conclusions of this paper are still robust.

5 Discussion

5.1 Theoretical contribution

The important theoretical contribution of this work is twofold.

Firstly, Network capacity has a significant positive impact on absorptive capacity under the framework of "resource, capacity and relationship", and absorptive capacity as a mediating variable has a significant positive impact on the service innovation performance of technology business incubators. In the service innovation process of technology business incubators, the absorption and application of knowledge by subjects build cross-organizational network cooperation based on trust (Nicotra et al., 2014; Ratten, 2016; Proeger, 2020). Only technology business incubators can fully utilize their own multi-dimensional and multi-module network capabilities to plan, coordinate and operate inter-organizational network relationships, thus facilitating incubators to fully develop their matching absorption capabilities (Dell'Anno and del Giudice, 2015; Franco et al., 2018; Kastelli et al., 2022). In turn, it can meet the real needs of incubators, improve incubation capacity and gain sustainable competitive advantages. First, the key to achieving innovation in technology business incubator services is to fully draw on and utilize the various value-based resources in the innovation incubation network relationships. The ability of technology business incubators to use network resources can help promote the aggregation and sharing of external horizontal and vertical innovation resources, enhance the effect of heterogeneous resource flow and transfer, and achieve efficient resource allocation and high-speed knowledge flow in the context of open innovation networks; second, the realization of knowledge accumulation in technology business incubators is based on the organizational learning ability of innovation incubation networks. Network organizational learning ability is an important method and path for technology business incubators to acquire value-based knowledge from external innovation networks, which can effectively prompt incubators to draw and store knowledge. At the same time, through knowledge integration, new knowledge and technologies are internalized into its own knowledge capabilities to provide quality incubation services for incubators and then realize service innovation; thirdly, technology business incubators make full use of network relationship interaction capabilities to maximize the integration and configuration of innovation incubation network relationships through comprehensive, multi-dimensional and multi-level in-depth interaction and communication, and are committed to building value co-creation. The "relationship rent" innovation network, with close cooperation and interdependence among them, lays the foundation for the technology business incubator to be in the active "knowledge field", and then realize knowledge accumulation and achieve the service innovation goal.

5.2 Management implications

This paper shows that the network capacity and absorptive capacity of incubators play an important role in the process of service innovation performance improvement. Therefore, the following 2 insights can be drawn.

Firstly, Technology incubators should strengthen resource acquisition and accumulation, and numerous studies have shown that incubator service innovation in China lacks the necessary capital, technology and talent. This study shows that incubator service innovation relies more on external resources, and with the construction of a large science and technology country to a strong science and technology country, network capacity and absorptive capacity are bound to become the source of competitive advantage for enterprises. First, incubators should focus on internal resource accumulation, strengthen the investment in the elements needed for service innovation, and strive to build core capabilities for service innovation. Second, external resources should be actively incorporated into the incubator service innovation network, and exchanges and learning with external incubators should be strengthened through building third-party platforms and supply chain collaboration to enhance the incubator's service innovation capabilities; finally, incubators should choose a service innovation enhancement path suitable for their own characteristics based on their own resource endowments. Secondly, incubators should pay attention to and enhance absorptive capacity. incubators should not only pay attention to and enhance the potential absorptive capacity to strengthen the acquisition and digestion of knowledge, but also pay attention to and enhance the actual absorptive capacity to strengthen the conversion and application of knowledge, thus enhancing service innovation performance.

6 Conclusion

This study constructs a theoretical framework and hypotheses of the impact of network capability within the "resource-capability-relationship" perspective, absorptive capacity on service innovation performance of technology business incubators. This study uses 234 Chinese incubators in the incubator network as samples and applies partial least squares structural equation modeling (PLS-SEM) and fuzzy-set qualitative comparative analysis (fsQCA) to explore the questions mentioned above. The following conclusions are drawn:

Firstly, according to the empirical results, it can be seen that 12 hypotheses in the conceptual model of this study passed the statistical test and 2 hypotheses did not pass the statistical test. The results show that the conceptual model proposed in this paper is better validated.

Secondly, in the service innovation process of technology business incubators, network capability (network resource patching ability and network cross-organization learning ability) has a significant positive impact on the service innovation performance of technology business incubators through the mediating role of absorptive capacity, and network relationship interaction capability has a positive impact on the service innovation performance through potential absorptive capacity.

Thirdly, the findings of this paper have important theoretical significance and practical value for the construction and management of innovation incubation network and efficient allocation of innovation resources, and the improvement of service innovation performance of technology business incubators. It provides policy suggestions and practice paths for incubator managers and decision makers.

7 Limitations and future research

There are still some shortcomings and areas for improvement in this paper. Firstly, the research sample of this paper is mainly selected from strategic emerging industries, and the single industry makes the scope of application of this paper needs to be further discussed and verified, and future research can try to expand the scope of industry research. Second, this paper only uses cross-sectional data in the empirical study, which may be biased, and future studies can try to use longitudinal comparative data. Finally, there may be collaborative effects of network capacity and absorptive capacity on the innovation performance of incubator services, which are considered but not in depth in the fsQCA approach, and their substitution or synergistic effects can be further studied in the future.

Data availability statement

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

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Methodology and software, HD and RM; formal analysis, HD and JL; resources and data curation, HD; investigation, HD; writing-original draft preparation, HD; writing-review and editing, HD and RM; supervision and project administration, JL; All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

Authors HD, RM, and JL are employed by Shaanxi Provincial Land Engineering Construction Group Co., Ltd.

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

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