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Cloud-native-based flexible value generation mechanism of public health platform using machine learning

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Abstract

Public health machinery learning platform based on cloud-native is a system platform that combines machine learning frameworks and cloud-native technology for public health services. The problem of how its flexible value is realized has been widely concerned by all public health network intelligent researchers. Thus, this article examines the relationship between cloud-native architecture flexibility and cloud provider value and the processes and the boundary condition by which cloud-native architecture flexibility affects cloud provider value based on innovation theory and dynamic capability theory. The results of a survey of 509 platform-related respondents in China show that cloud-native architecture flexibility is positively related to cloud provider value, and both absorptive capacity and supply chain agility mediate the above-mentioned effect. Moreover, R&D subsidies strengthen both the positive relationship between absorptive capacity and cloud provider value and the relationship between supply chain agility and cloud provider value. In this study, cloud-native architecture flexibility, unit absorptive capacity, supply chain agility and R&D subsidies are considered into a flexible value generation mechanism model that extend the relevant research on the value generation mechanism of information system under the background of network intelligence, and to provide relevant enterprises with suggestions on upgrade strategies.

Keywords Cloud-native architecture flexibility · Cloud provider value · Absorptive capacity · Supply chain agility

1 Introduction

Public health machine learning provides an important assistance for people and government organizations to address key challenges of emergencies through the analysis of information from epidemic surveillance, prevention, treatment, and drug research. Due to the randomness of public health events, public health machine learning software should be flexible and reliable and be able to timely conduct low-level mediation and high-level collaboration according to actual needs. Cloud-native, as the technical standard for a new generation of software architectures [1], has been applied to public health machine learning in response to protein structure prediction, COVID-19 research, and other fields. However, software companies do not understand their promotion value, which requires research on cloud-native flexible value production mechanisms to understand the factors affecting its flexible value, and thus promotes cloud-native is widely used in public health machine learning application software development, so that the public health-related research works better.

Due to its technical excellence, the cloud-native has received extensive attention from the academic community, and a large number of scholars have conducted research on it [2]. However, relatively few researches have

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pay attention to the value of its architecture flexibility, especially there are fewer documents that incorporate the benefits of collaboration from internal operational efficiency into the study of the value of cloud-native architecture flexibility to cloud providers. This paper adopts innovation theory and dynamic capability theory to construct a model of flexible value generation mechanism of cloud-native architecture. In order to test our concept model, we collected survey data from the members of Fujian Software Association and Shenzhen Software Association in China and finally we obtain 509 valid observations. The empirical results show that cloud-native architecture flexibility has a positive impact on cloud provider value, and both absorptive capacity and supply chain agility mediate the effect of cloud-native architecture flexibility on cloud provider value. Furthermore, R&D subsidies strengthen both the positive relationship between absorptive capacity and cloud provider value and the relationship between supply chain agility and cloud provider value. Our findings extend the research on cloud-native architecture by systematically explore the cloud provider value-generating mechanism and have important implications for public health software companies in applying cloud-native solutions in public health machine learning software.

2 Literature review and hypotheses development

For cloud consumers who using public health machine learning based on cloud-native, the product it provides is actually a new type of technology outsourcing service. There is a substantial relationship between the cloud provider of public health machine learning platform and cloud consumers. Cloud consumers sign an SLA (service level agreement) and entrust the cloud provider to perform some services on their behalf, so as to promote better completion of related activities [3]. At the same time, in order to complete the entrustment of cloud consumers, the cloud provider will also sign SLA refinement agreements with third-party service providers and internal service teams that serve itself to form a principal-agent relationship to eventually realize the flexible value of the cloud-based public health machine learning platform based on cloud-native. The relationship between the parties is shown in Fig. 1.

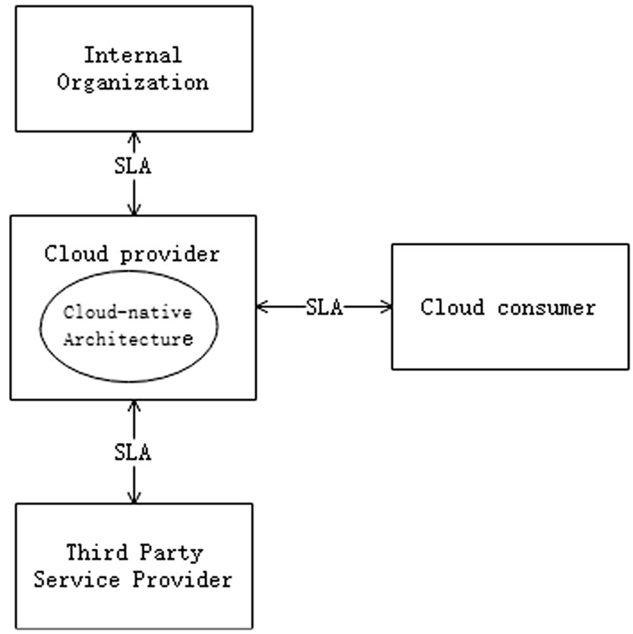


Fig. 1 Schematic diagram of the principal-agent relationship of cloud-native architecture flexible value generation

2.1 Cloud-native architecture flexibility and internal organization

Cloud-native architecture flexibility is the use of cloud native technology to build flexible, manageable, and observable loosely coupled systems to cope with dynamic changes in the external environment, such as containers, service grids, microservices, immutable infrastructure, and declarative apis are specific manifestations of cloud-native architecture flexibility.

According to innovation theory, enterprises need to continuously introduce production factors and production conditions that were not available before into the original system in order for enterprises to continue to develop. As the engine of the cloud provider's business activities, the internal organization should be an innovative organization [4]. It needs to continuously transform knowledge into new products, new processes, and new services in order to finally continuously identify and satisfy the continuous develop the need to obtain a competitive advantage [5]. Therefore, absorptive capacity is the main ability of the internal organization to influence the value of the enterprise.

Cloud-native architecture flexibility can improve the absorptive capacity by increasing the coverage of knowledge acquired by the members of the internal organization of the cloud provider and the richness of knowledge content [6]. In particular, this capability can help internal organizations simplify, change, and connect, to promote communication between data information inside and outside the organization. Through the effective communication of the internal organizational information, it can effectively expand the range of cloud suppliers to obtain knowledge, enhance the speed of different knowledge acquisition, break the intellectual islands in the organization. Compatibility enables the sharing of richer data formats and functional resources between internal organizations and other related organizations, realizes the exchange of dissimilar knowledge, and increases the source of enterprise knowledge [7]. Previous studies have shown that general dissimilar knowledge is more beneficial The generation of new knowledge promotes the mixing process of two sets of inconsistent information, which is conducive to the integration of knowledge information by internal organizations [8], conversion, coordination, recoding, and alienation processing [9]. Modularization enables internal organizations to quickly modify, delete, and add various resources to meet various knowledge management needs, so that internal organizations can more easily combine existing knowledge with newly acquired and absorbed knowledge to achieve knowledge complementarity [10].

According to the summary, cloud-native architecture flexibility can provide convenient support services for the improvement of absorptive capacity, serve the various links of knowledge acquisition, absorption, transfer, transformation, and innovation, and provide a necessary foundation for the improvement of the absorptive capacity of internal organizations condition. Therefore, this article expects that cloud-native architecture flexibility is positively related to absorptive capacity and assumes the following:

H1 Cloud-native architecture flexibility positively affects absorptive capacity.

2.2 Cloud-native architecture flexibility and third-party service providers

The cloud-native architecture is an open software architecture that can easily integrate resources from third-party cloud providers. It requires the joint contact and cooperation of all parties to form an effective supply chain to provide services for cloud consumers. Supply chain agility is defined as the ability of cloud providers and supply chain partners to cope with these complexities through effective collaboration [11]. Supply chain agility can effectively reflect the interconnection between cloud providers and relevant various third-party service providers, and mutually promote effective changes between all parties to deal with internal and external uncertainties [12].

The connectivity through the cloud-native architecture can help cloud providers communicate and integrate information resources with third-party service providers more conveniently through application programming interfaces. Cloud providers can more effectively integrate information flows from all parties. Understand the development and operation of services provided by third-party service providers, external service containers and external virtual machines in the entire supply chain, so as to improve efficiency of the overall supply chain [13]. At the same time, through connectivity, supply chain partners realize the interconnection of different systems, realize the sharing of knowledge of all parties, and the coupling of business processes, thereby increasing mutual trust between supply chain partners and promoting cloud providers and third parties. The real-time matching of technology between service providers will ultimately enhance the agility of the supply chain among supply chain partners, improve efficiency, and reduce costs [14]. Secondly, the compatibility of cloud-native architecture can help cloud providers realize the application of heterogeneous data, information, and knowledge across organizational boundaries within the cloud provider's organization [15], which will promote mutual exchanges between cloud providers and third-party service providers. Cooperate, execute complex business activities together, and develop new innovation opportunities through cooperation. For example, third-party service providers can choose their own suitable development languages and databases to develop various new services to support the improvement of cloud provider services and new services [16]. At the same time, compatibility helps the system interconnection between cloud providers and third-party service providers. Through the sharing of data and information, it can increase trust, risk sharing, and return sharing [17]. Finally, through a high degree of cloud-native architecture modularity, the interoperability between the containers in the system becomes possible. This modularity can help cloud providers adjust their original architectures in a timely manner. System integration and resource reconfiguration with third-party service providers can effectively respond to market changes together, form process integration and network integration through mutual cooperation [18], promote the rapid development of new services, and improve the agility of the overall supply chain. In summary, the flexibility of the cloud-native architecture is conducive to promoting information sharing among supply chain partners, giving full play to their respective advantages, and quickly adjusting their resources according to the actual internal and external conditions, and promoting the formation of supply chain agility. Therefore, this article expects that cloud-native architecture flexibility is positively related to the agility of the supply chain and proposes the following assumptions:

H2 Cloud-native architecture flexibility is positively affecting the agility of the supply chain.

2.3 Absorptive capacity and cloud provider value

The essence of absorptive capacity is to recombine and innovate the original basic knowledge through dissimilar knowledge, so as to realize the dynamic capability of the organization [19], which is critical important for the transformation and utilization of new knowledge of an enterprise. The improvement of the internal organization of the cloud provider for external knowledge acquisition, dissemination, transformation, and innovation is conducive to changing the original knowledge structure rigidity which is not conducive to the operation process [20]. It is beneficial to the cloud provider's internal organization by improving the knowledge acquisition and transmission capabilities. The sharing of information and the understanding of each other's views promote mutual communication and coordination. Knowledge will be internalized into the knowledge structure of internal organization members [21] and stored in the internal organization's knowledge base. When internal members need it, they can quickly extract this knowledge from the internal organization's knowledge base and undergo transformation and innovation. Efficient use of it in practice is conducive to improving the understanding among internal organization members and finally putting the transformed new knowledge into cloud-native architecture development, operation and maintenance, and service instantiation, so as to realize the value of knowledge and promote the improvement of overall cloud provider collaboration value creates a competitive advantage and sustainable development for cloud providers. Absorptive capacity is not only conducive to improving the operational capabilities of cloud providers, but also conducive to the continuous accumulation and transformation of cloud providers' knowledge, so as to continuously respond to knowledge competition and continue to create and utilize knowledge as a key dynamic capability that can help cloud providers to provide providers continue to optimize internal performance, launch new services and products that adapt to external changes, and obtain and maintain competitive advantages. In summary, the absorptive capacity is not only conducive to improving cloud providers value' collaboration, but also conducive to improving the original service or product's performance, open up new markets, businesses, and customers, and realize the performance value of cloud providers. Therefore, this article expects that absorptive capacity is positively correlated with cloud provider value and assumes the following:

H3 Absorptive capacity is positively affecting cloud providers value.

2.4 Supply chain agility and cloud provider value

Facing different types of uncertainties and changes that are rapidly changing internally and externally, organizations need to unite the entire supply chain to respond effectively and efficiently [22]. Supply chain agility is an outstanding capability of cloud suppliers, which can help them realize the sharing of internal and external information and resources to respond to changes in cloud consumers and the market, and grasp market information in a timely manner, and develop new products or services, open up new customers and markets. This kind of resource reorganization and integration between supply chain partners improves the degree of cooperation between supply chain partners, enabling cloud providers to perceive market changes in real time, thereby reducing operating costs due to demand uncertainty. At the same time, the agility of the supply chain has enabled cloud providers and supply chain partners to cooperate and understand each other more. Due to the increase in common attributes, they have more in common in terms of vision planning and business process formulation. This helps reduce the internal supply chain potential conflicts and opportunistic behavior, prompting the focus and allocation of resources, improve the overall performance of cloud providers and cloud providers between supply chain partners. According to the summary, supply chain flexibility is not only conducive to improve the internal efficiency of enterprises, but also promotes the comprehensive service capabilities of cloud providers and enables cloud providers to obtain performance value. Therefore, this article expects that supply chain agility is positively correlated with cloud provider value and assumes the following:

H4 Supply chain agility is positively affecting cloud providers value.

2.5 Cloud-native architecture flexibility and cloud provider value

As a system architecture that supports cloud provider business, cloud-native architecture can help cloud providers cope with internal and external changes and form core competitiveness This gives cloud providers the ability to remain competitive in the face of external challenges [23]. Cloud-native architecture connectivity is conducive to the sharing of internal and external information and resources by cloud providers and promotes communication and coordination between internal and external cloud providers to cope with complex and dynamic environments and improve cloud providers' operations ability to enhance the value of collaboration. And through the extensive connection of third-party service provider systems, it is helpful to improve the response ability to the needs of cloud consumers and promote the generation of performance value. Cloud-native architecture compatibility is conducive for cloud providers to improve the coordination and communication between internal organizations and between cloud providers and third-party service providers through the compatibility of programming interfaces, data interfaces, etc., so that cloud providers get the value of collaboration. Through the improvement of mutual cooperation ability, it is conducive for all parties to better play their own advantages and dynamically transfer all kinds of high-efficiency resources to the business process of the cloud provider to cope with the ever-changing business environment and enable the cloud provider to gain performance value. The flexible modularity of the cloud-native architecture allows cloud providers to quickly adjust, reconfigure original resources and dynamically integrate new resources into business services, improve the cloud provider's operational performance, and enable them to obtain collaboration value. Changes in the original needs of cloud consumers [24], opening up new services, accepting new customers, opening up new markets, and enabling cloud providers obtain performance value. In summary, a cloud provider with excellent cloud-native architecture flexibility can enhance the acquisition and sharing of information and resources, expand market scope, improve decision-making capabilities, stimulate innovation and actively respond to changes, and realize the collaboration value and performance value of cloud providers. Therefore, this article expects that cloud-native architecture flexibility is positively related to cloud providers value and assumes the following:

H5 Cloud-native architecture flexibility is positively affecting cloud providers value.

2.6 The moderating role of direct R&D subsidies

The research and development activities of public health machine learning software are very complex, and it is difficult to guarantee the enterprise to obtain the expected value. Moreover, there is a large information asymmetry between the implementers and investors of the research and development activities of public health machine learning software, which increases the difficulty for enterprises to achieve the expected goals. The government's subsidy for public health machine learning software opens up another channel for R&D investment, which can alleviate enterprises' fear of the uncertainty of R&D results to a certain extent. Existing research results also show that R&D subsidies promote the realization of enterprise value. For example, P Deng et al. believe that tax incentive policies have a significant role in promoting enterprise R&D investment [25], which is conducive to promoting the influence of absorptive capacity within an organization on enterprise value. M Jessica et al. studied the impact of tax incentives targeting young innovative firms [26] and showed that long-term tax credit can lead to the improvement of enterprise value investment, which is conducive to strengthening the cooperation between enterprises and external countries and enhancing the influence of supply chain agility on enterprise value [27]. Therefore, this paper proposes that R&D direct subsidy has a moderating effect on absorptive capacity and cloud supplier value as well as supply chain agility and cloud supply value.

H 6a R&D subsidies strengthen the positive relationship between supply chain agility and cloud provider value.

H 6b R&D subsidies strengthen the positive relationship between absorptive capacity and cloud provider value.

Enterprise size is considered to be a factor that affects performance of cloud providers. There are significant differences in the resources invested by large and small companies. Meanwhile, cloud providers in different industries have different amounts of challenges, and the investment they bring is also different. Here use these two factors as control variables to control their possible confounding effects.

Fully on the, proposed the following cloud-native architecture of the flexible value generation mechanism model, as in Fig. 2.

3 Research design

In order to check the above cloud-native architecture value generation mechanism model, we first design the cloud-native architecture value generation mechanism hypothesis model scales and questionnaires based on existing related empirical research, and adjust the preliminary questionnaires through pre-tests. The results of pretest indicate that all constructs in this study have good reliability and validity. Then we collect data by issuing questionnaires and expounded on the selection of samples and analyze the characteristics of the samples. Finally, the data analysis method is introduced.

3.1 Research context

We choose software industry and other relevant industry as our research context because we can easy to observe and measure the flexibility of cloud-native architecture, absorptive capacity, supply chain agility in these industry. According to the purpose of the research, it is determined

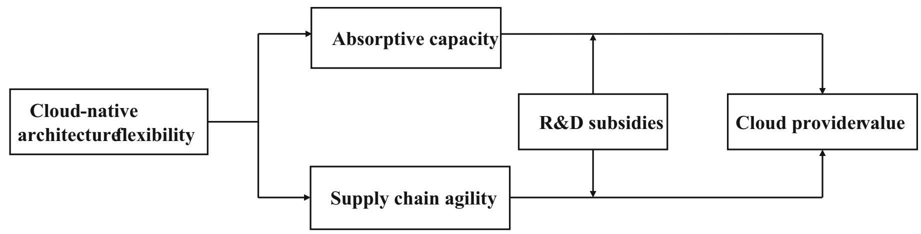


Fig. 2 Conceptual framework

that the object of this research is an organization that adopts a cloud-native architecture. The software industry, education, research and industry, the manufacturing industry 's information center is the main cloud-native architecture development organization industry is located, and the three industry organizations practitioners because of educational background, business experience, and other and other industry practitioners compared with general have a deeper understanding of cloud-native architecture, and surveys of these three industry organizations can better represent the true situation of cloud providers. Therefore, this article chooses the software industry, education and research industry, and manufacturing industry as the subjects of the questionnaire.

3.2 Data source

This article uses a multiple-source, multi-respondent method to collect data; multiple-informant approach is conducive to improving the quality of the questionnaire and reducing systematic measurement errors [28]. In this study, questionnaires were distributed in the form of on-site combined with the Internet. The pre-test subjects are the teachers and students of the computer department of a provincial medical university who fully understand the cloud-native architecture, and the architects of a public health machine learning software developer. A total of 162 valid questionnaires were collected, with one exclusive question and one test question. A total of 159 questionnaires meeting the requirements were collected. The effective questionnaire rate was 98%.

The formal survey is mainly through the cooperation with senior experts of cloud-native architecture, Fujian Software Association and Shenzhen Software Association, to issue questionnaires to organizational seniors and architects engaged in the research and development of cloud-native architecture. Questionnaires were collected to meet the requirements of 509 copies, sample type of business, enterprise scale in line with the basic situation of China's cloud computing industry, in line with Anderson and Gerbing [29] requirements on sample size.

3.3 Scale

In order to maintain the reliability and validity of the measurement, this study uses the maturity scales in authoritative journals in the field of management. By English translation comparisons and in-depth interviews method of scale in a few words made changes to the wording so that the whole scale greater clarity and avoid misunderstandings, the detailed scale is as follows:

3.3.1 Cloud-native architecture flexibility

According to previous research, cloud-native architecture flexibility includes three dimensions: connection lines, compatibility, and modularity. Here, four scales proposed by Ray et al. (2005) [30] and Saraf et al. (2007) [31] are used to measure cloud-native architecture flexibility. These measures asked each respondent to rate the public health machine learning software architecture they had developed.

3.3.2 Supply chain agility

According to previous research, supply chain agility includes four dimensions. Visibility reflects the extent to which information integration in the supply chain, which is measured here based on the scale of the three projects proposed by Abdelilah [12] and Christopher [21]. The joint planning mainly judges that the cloud provider and the supply chain partner jointly plan the cloud consumer demand forecast, the introduction period of new products or services, and the degree of service support through the four projects proposed by Simatupang and Sridharan [32]. Integration process reflects streamline and automate business processes throughout the supply chain, according to Lee and Whang [33] to measure the four measurement items proposed. Shared values reflect the cloud provider - and supply chain partners have a consistent common strategic objectives, where according to Li and Lin [34] proposed three measure items.

3.3.3 Absorptive capacity

According to previous studies, the amount of absorption capacity includes acquisition, assimilation, transformation, and utilization four dimensions. Here, according to the characteristics of the cloud-native architecture, the project proposed by Pavlou and Sawy [35] and Jansen et al. [36] is adapted. It is measured by the interviewees judging the company's four aspects of acquisition, assimilation, conversion, and utilization. Acquisition, assimilation, and utilization of San dimensions. Each dimension has three projects, the conversion dimension by two project components.

3.3.4 Cloud provider value

According to previous research, cloud provider value is a secondary structure with two dimensions: performance value and assistance value. The performance value reflects the direct value of the cloud-native architecture to the cloud provider, which is measured by the four projects proposed by Zhu and Kraemer [37]. The value of assistance reflects the impact of the cloud-native architecture on the internal operations of the cloud provider, which is measured by the three projects proposed by Luo et al. [38].

3.3.5 R&D subsidies

According to previous studies, R&D subsidies include national special funds such as science and technology support program, provincial special funds such as technological innovation of small- and medium-sized enterprises, and provincial awards for key new products or high-tech products, most studies divided the collected direct subsidies related to various technological innovations obtained by enterprises by the current year's operating income, and obtained a direct subsidy ratio data as the measurement of R&D subsidies. In our sample, only part of firms have received R&D subsidies from the government; we use a binary variable to measure R&D subsidies. Specifically, if the firm received R&D subsidies from the government, then variable "R&D subsidies" equals to 1, else 0.

3.4 Empirical model

The hypotheses of this study were examined by the following five models.

$$\text{Model1} : \text{absorptive capacity}_i = \beta_{10} + \beta_{11}\text{Cloud} - \text{native architecture flexibility}_i + \text{Control} + \varepsilon_{1i} \tag{1}$$

$$\text{Model2} : \text{supply chain agility}_i = \beta_{20} + \beta_{21}\text{Cloud} - \text{native architecture flexibility}_i + \text{Control} + \varepsilon_{2i} \tag{2}$$

$$\text{Model3} : \text{Cloud provider value}_i = \beta_{30} + \beta_{31}\text{Cloud} - \text{native architecture flexibility}_i + \text{Control} + \varepsilon_{3i} \tag{3}$$

$$\text{Model4} : \text{Cloud provider value}_i = \beta_{40} + \beta_{41}\text{Cloud} - \text{native architecture flexibility}_\text{i} + \beta_{42}\text{absorptive capacity}_\text{i} + \beta_{43}\text{supply chain agility}_\text{i} + \text{Control} + \varepsilon_{4\text{i}} \tag{4}$$

$$\text{Model5} : \text{Cloud provider value}_i = \beta 50 + \beta 51\text{Cloud} - \text{native architecture flexibility}_i + \beta 52\ \text{absorptive capacity}_i + \beta 53\ \text{supply chain agility}_i + \beta 54 R\&D\ \text{subsidies}_i + \beta 55\ \text{absorptive capacity}_i \times R\&D\ \text{subsidies}_i + \beta 56\ \text{supply chain agility}_i \times R\&D\text{subsidies}_i + \text{Control} + \varepsilon_{5i} \tag{5}$$

Model 1 is used to test hypothesis H1, model 2 is used to test hypothesis H2, model 3 is used to test hypothesis H5, model 4 is used for testing hypotheses H3 and H4, model 1, model 2, model 3, and model 4 are used for testing mediating effect of absorptive capacity and supply chain agility on the relationship between cloud-native architecture flexibility and cloud provider value. Model 5 is used to test hypothesis H6a and H6b.

4 Results

We first give the descriptive of our research sample and then provide the reliability and validity testing results. Finally, we examine all the hypotheses in the above section by 5 regression models. Specifically, we will test main effect, mediating effects and moderating effects in this section.

Table 1 Descriptive of sample companies ($N = 509$)

Feature	Category	Sample size	Percentage (%)
Enterprise size	Less than 50 people	58	11.39
	50–200 people	308	60.51
	200–1000 people	136	26.72
	More than 1000 people	7	1.38
Industry	IT/software and hardware services/e-commerce/internet operations	146	28.68
	Education/training/research/academy	236	46.37
	Manufacturing	127	24.95

4.1 Descriptive statistical analysis of the overall sample

The distribution of characteristics of the sample companies in this study is shown in Table 1.

4.2 Reliability and validity analysis

The main constructs of this research are cloud-native architecture flexibility, supply chain agility, absorptive capacity, and cloud provider value, wherein the flexible cloud-native architecture constructs the first order, so calculated Cronbach's α coefficient is 0.886 > 0.8, having a good reliability. Following Bagozzi and Yi [39], we integrate the main research constructs of cloud-native architecture flexibility, supply chain agility, absorptive capacity and cloud provider value with a full confirmatory factor analysis, the result (χ^2 = 715.757, DF = 578, CFI = 0.986, TLI = 0.985, RMSEA- = 0.022) indicates that the present model fits well with the data. Four factors were higher than the load question item 0.6, and significantly, the mean and variance were extracted 0.677 > 0.5; a combination of reliability was 0.893 > 0.7, having good validity of polymerization. The square root of the flexible average extraction variance of the cloud-native architecture is larger than that of the other three constructs, and it has a good construct validity [40].

Supply chain agility, absorptive capacity, and cloud provider value are second-order constructs, which only have combined reliability, and the construct validity is directly calculated. The results in Table 2 show that standard factor loading of all items is greater than 0.6 and significant, all dimension composite reliabilities are greater than 0.7, and all dimension average variances extracted are greater than 0.5, which suggest that all constructs have good convergent validity [40]. As well as, for each construct, the square root of average variance extracted is much higher than its highest correlation coefficient with other constructs, providing robust support of discriminant validity. Thus, all constructs have good construct validity in this study.

4.3 Test of common method bias

Since the authors collected data using a single source, common method bias may exist because the nature of this study is cross-sectional. We conducted Harman's one-factor test without rotation to monitor the level of the spurious covariance shared among all the constructs' items in this study. The exploratory factor analysis results indicate that the first factor explains 24.905% of the total variance, which is far below the 50% threshold. Hence, we have evidence that a single factor does not create a major portion of the variance, and common method bias is not a serious issue and does not strikingly affect the subsequent data analysis results.

4.4 Regression analysis and hypothesis testing

The regression analysis results of the four empirical models of this study are listed in Table 3.

4.4.1 Test of main effects

H1 believes that cloud-native architecture flexibility has a positive effect on absorptive capacity. In model 1 of Table 3, the regression coefficient of cloud-native architecture flexibility β_{11} = 0.252, $p < 0.01$. So H1 is supported.

H2 proposes that cloud-native architecture flexibility is positively related to the agility of the supply chain. In model 2 of Table 3, the regression coefficient of cloud-native architecture flexibility β_{21} = 0.320, $p < 0.01$. Therefore, H2 is received support.

H3 assumes that the absorptive capacity of the cloud provider will have a positive impact on cloud provider value, and H4 proposes the positive relationship between supply chain agility and cloud provider value. In Model 4 in Table 3, the regression coefficient of absorptive

Table 2 Validity assessment

Factor	Dimension	Item	Loading	Composite reliability	Average variance extracted
Supply chain agility	Visibility	VI1	0.90	0.86	0.67
		VI2	0.84		
		VI3	0.71		
	Joint planning	JP1	0.62	0.81	0.52
		JP2	0.79		
		JP3	0.69		
		JP4	0.78		
	Integration process	IP1	0.71	0.84	0.51
		IP2	0.72		
		IP3	0.78		
		IP4	0.70		
		IP5	0.67		
	Shared values	SV1	0.77	0.79	0.56
		SV2	0.83		
		SV3	0.63		
Absorptive capacity	Acquisition	AC1	0.60	0.77	0.53
		AC2	0.77		
		AC3	0.80		
	Assimilation	AS1	0.76	0.87	0.70
		AS2	0.86		
		AS3	0.88		
	Transformation	TR1	0.66	0.76	0.61
		TR2	0.89		
	Utilization	UT1	0.68	0.79	0.56
		UT2	0.75		
		UT3	0.81		
Cloud provider value	Performance value	PV1	0.88	0.85	0.59
		PV2	0.81		
		PV3	0.62		
		PV4	0.73		
	Assistance value	AV1	0.91	0.90	0.76
		AV2	0.90		
		AV3	0.80		

capacity β_{42} = 0.274, $p < 0.01$; the regression coefficient of supply chain agility β_{43} = 0.601, $p < 0.01$. Therefore, both Hypothesis H3 and Hypothesis H4 are supported.

Hypothesis H5 believes that cloud-native architecture flexibility has a positive effect on cloud provider value. In Model 3 in Table 3, the regression coefficient of cloud-native architecture flexibility β_{31} = 0.369, $p < 0.01$. Therefore, H5 is supported.

4.4.2 Test of mediation effect

This study uses both the three-step method of Bar-on and Kenny [41] and the process (Model 4) proposed by Hayes [42] to test the mediating effects of absorptive capacity and the agility of the supply chain on the relationship between architectural flexibility and cloud provider value.

First, in Model 3 in Table 3, the regression coefficient of cloud-native architecture flexibility is 0.369, $p < 0.01$. The relationship between the independent variable (cloud-native architecture flexibility) and the dependent variable (cloud provider value) is significantly positive. Secondly, in model 1, the regression coefficient of cloud-native architecture flexibility β_{11} = 0.252, $p < 0.01$, and cloud-native architecture flexibility positively affects absorption capacity; in model 2, the regression coefficient of cloud-

Table 3 Regression analysis results

Model Dependent variable	Model 1 Absorptive capacity	Model 2 Supply chain agility	Model 3 Cloud provider value	Model 4 Cloud provider value	Model 5 Cloud provider value
Enterprise size dummy variable 1	0.081	0.066	− 0.174	− 0.236**	− 0.245***
	(0.084)	(0.088)	(0.113)	(0.091)	(0.089)
Enterprise size dummy variable 2	0.137	0.026	− 0.071	− 0.125	− 0.165*
	(0.093)	(0.097)	(0.125)	(0.101)	(0.099)
Enterprise size dummy variable 3	0.248	− 0.331	− 0.369	− 0.238	0.106
	(0.234)	(0.245)	(0.316)	(0.255)	(0.260)
Industry dummy variable 1	− 0.086	− 0.040	− 0.061	0.013	− 0.013
	(0.062)	(0.065)	(0.084)	(0.067)	(0.066)
Industry dummy variables 2	0.005	− 0.025	0.160	0.174**	0.161**
	(0.073)	(0.076)	(0.098)	(0.079)	(0.078)
Cloud-native architecture flexibility	0.252***	0.320***	0.369***	0.108***	0.103***
	(0.031)	(0.033)	(0.042)	(0.037)	(0.036)
Absorptive				0.274***	0.237***
capacity				(0.057)	(0.056)
Supply chain				0.601***	0.524***
agility				(0.055)	(0.057)
Absorptive capacity					0.286**
× R&D subsidies					(0.114)
Absorptive capacity					0.270**
× R&D subsidies					(0.115)
Constant	2.431***	2.527***	2.443***	0.258	0.593***
term	(0.117)	(0.122)	(0.157)	(0.184)	(0.208)
N	509	509	509	509	509
F	12.08***	17.37***	14.78***	52.07***	42.41***
adj. R^2	0.116	0.162	0.140	0.455	0.473

Note: Standard errors in parentheses

*$p < 0.1$

**$p < 0.05$

***$p < 0.01$

native architecture flexibility β_{21} = 0.320, $p < 0.01$, The cloud-native architecture flexibility positively affects the agility of the supply chain agility; the relationship between the independent variable (cloud-native architecture flexibility) and the both two mediating variables (absorption capacity and supply chain agility) is significantly positive. Finally, in Model 4, the regression coefficient of absorptive capacity β_{42} = 0.274, $p < 0.01$; the regression coefficient of supply chain agility β_{43} = 0.601, $p < 0.01$; the two mediating variables have significant effects on the value of the dependent variable cloud provider. Therefore, according to the three-step method of Baron and Kenny [41], absorptive capacity and supply chain agility have significant mediation effects on the relationship between cloud-native architecture flexibility and cloud provider value.

In addition, it should be noted that in Model 4 in Table 3, after adding two mediating variable absorptive capacity and supply chain agility, the independent variable (cloud-native architecture flexibility) still has a significant positive impact on the value of the dependent variable (cloud provider value), regression coefficient β_{51} = 0.108, $p < 0.01$, which shows that absorptive capacity and supply chain agility only partially mediate the relationship between cloud-native architecture flexibility and cloud provider value.

We also uses the more popular Hayes [42] program Process to re-examine the above-mentioned mediating relationship. The Process program uses

Table 4 Testing mediating effects in Process model

Effect name	Effect size	Standard error	LLCI	ULCI
Indirect effects of absorptive capacity	0.069	0.021	0.031	0.112
Indirect effects of supply chain agility	0.192	0.028	0.138	0.248
Joint indirect effects of absorptive capacity and supply chain agility	0.261	0.034	0.193	0.325
Direct effects of cloud-native architecture flexibility	0.108	0.037	0.035	0.181

the 95% confidence interval of the indirect effect to determine whether the mediating effect is significant. When the 95% confidence interval does not contain 0, the mediating effect is significant. Table 4 lists the calculation results of Bootstrap for 10,000 times of the mediating effect test program Process (Model 4).

As we can see from Table 3, the indirect effect of absorptive capacity on the relationship between cloud-native architecture flexibility and cloud provider value is significantly positive, the regression coefficient b = 0.069, and 95% confidence level bias correction confidence interval CI = [0.031, 0.112], the upper and lower limits of the confidence interval are both greater than 0. The confidence interval does not contain 0, so the mediating effect of absorptive capacity is significant; similarly, the indirect effect of supply chain agility on the relationship between cloud-native architecture flexibility and cloud provider value is also significantly positive, the regression coefficient b = 0.192, 95% confidence bias modified confidence interval CI = [0.138, 0.248], the confidence interval does not contain 0. Therefore, the mediating effect of supply chain agility is also significant; accordingly, the joint indirect effects of absorptive capacity and supply chain agility are 0.261.

In addition, after adding two mediating variables, the direct effect of cloud-native architecture flexibility on cloud provider value remains significantly positive, the regression coefficient b = 0.108, and the 95% confidence bias correction confidence interval CI = [0.035, 0.181], the upper and lower limits of the confidence interval are both greater than 0, the confidence interval does not include 0, so the direct impact of cloud-native architecture flexibility on cloud provider value is significant, which indicates that the combined effects of absorbing capacity and supply chain agility are only partially adjusted to the cloud-native architecture flexibility affect the value of cloud providers.

4.4.3 Test of moderation effects

Hypothesis H6a proposes that R&D subsidies reinforce the positive relationship between absorptive capacity and cloud provider value. It can be seen from model 5 in Table 2, the regression coefficient of interaction term between absorptive capacity and R&D subsidies β_{55} = 0.286, $p < 0.05$. Thus, H6a is received support.

Similarly, hypothesis H6b assumes that R&D subsidies reinforce the positive relationship between supply chain agility and cloud provider value. It can be seen from model 5 in Table 2, the regression coefficient of interaction term between supply chain agility and R&D subsidies β_{56} = 0.270, $p < 0.05$. Thus, H6b is received support.

Figure 3 plots the interactive effect of R&D subsidies on the positive relationship between absorptive capacity and cloud provider value. From the figure we can see: When R&D subsidies is low, the relationship between absorptive capacity and cloud provider value is positive, but when R&D subsidies is high, such positive relationship turns to be higher. Therefore, R&D subsidies substantially strength the relationship between absorptive capacity and cloud provider value, which is consistent with hypothesis H6a.

Figure 4 plots the interactive effect of R&D subsidies on the positive relationship between supply chain agility and cloud provider value. From the figure we can see: When R&D subsidies is low, the relationship between supply chain agility and cloud provider value is positive, but when R&D subsidies are high, such positive effect turns to be higher. Therefore, R&D subsidies significantly strength the relationship between supply chain agility and cloud provider value, which is also consistent with hypothesis H6b.

In conclusion, both the proposed moderating effects of hypotheses H6a and H6b are all supported in our study. Particularly, R&D subsidies moderate the relationship between absorptive capacity and cloud provider value; and R&D subsidies also strength the relationship between supply chain agility and cloud provider value.

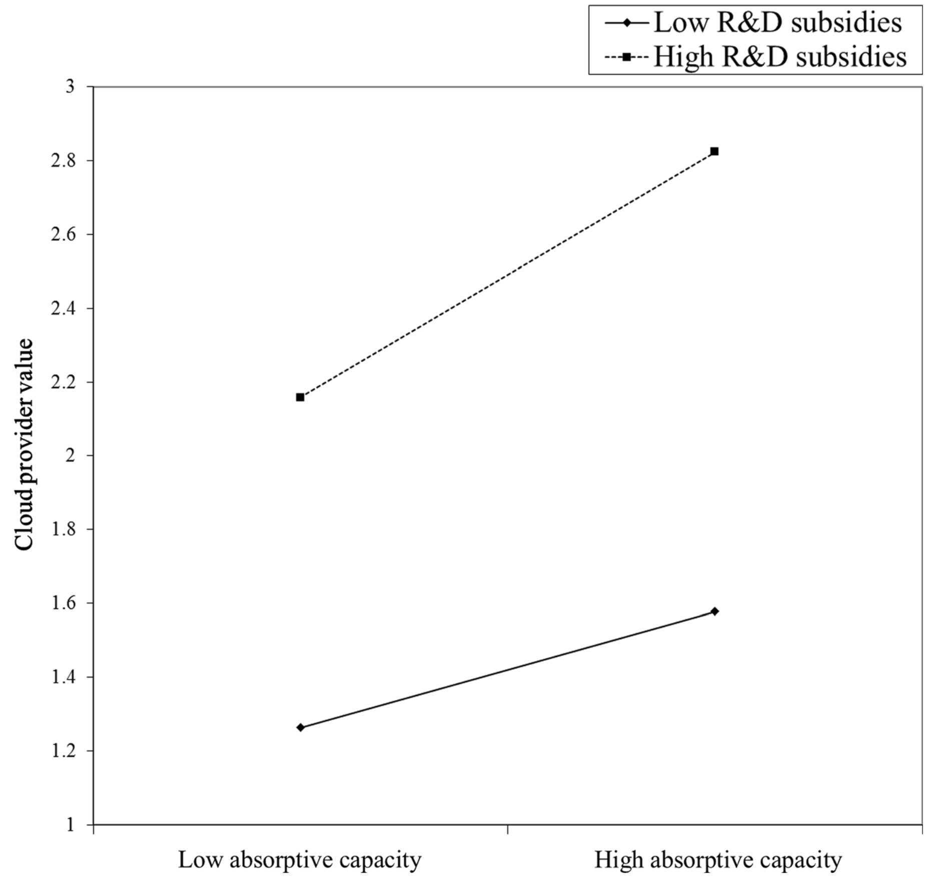
Therefore, all hypotheses in this study are received support.

5 Discussion

5.1 Conclusion

(1) Cloud-native public health machine learning platforms are both a product and a service, such as those offered by Microsoft, Frost & Sullivan, and others. In order to clarify the structure of its flexible value

Fig. 3 The interactive effect of R&D subsidies on the positive relationship between absorptive capacity and cloud provider value



generating organization, this article systematically analyzes the principal-agent relationship of its actual value generation and makes clear the process of its flexible value generation. Flexibility of native cloud architecture, unit absorption capacity, agility of supply chain and R & D subsidies subjects are integrated into the framework of flexible value generation mechanism, and a theoretical model is proposed. This expands the field of information system management research and provides a basic framework for the later related research.

(2) The theoretical hypotheses put forward in this study are all supported by statistical test results. Data analysis shows that the mediation effect cannot fully explain the impact of cloud-native architecture flexibility on the value of cloud-native architecture flexibility. Cloud-native architecture flexibility will directly affect the implementation of SLAs confirmed by cloud providers and cloud consumers and the degree of assistance between internal organizations, that is, it directly affects the generation of flexible value. And cloud-native architecture flexibility will affect the absorptive capacity of internal organizations, making internal organizations more innovative, conducive to the acquisition, absorption, dissemination and creation of knowledge, and generating better services and products to create new value points for cloud providers. Affect the generation of flexible value. While affecting the absorptive capacity of internal organizations, cloud-native architecture flexibility is also conducive to improving the agility of the overall supply chain, conducive to the integration of cloud providers into the cloud ecosystem, providing a support platform for mutual cooperation between all parties, and better responding to internal and external changes. To meet the SLA requirements of cloud consumers, create new products and services, and bring value to cloud providers.

(3) Cloud-native flexible architecture not only will bring to the cloud provider performance value, will bring value to their collaboration, which further expand the scope of research information systems value.

(4) Through empirical certification, R & D subsidies facilitate the impact of strengthening the absorption capacity of the enterprise and supply chain agility to the value of cloud providers. This is a major supplement to the current mainstream research model and further explains the importance of R&D

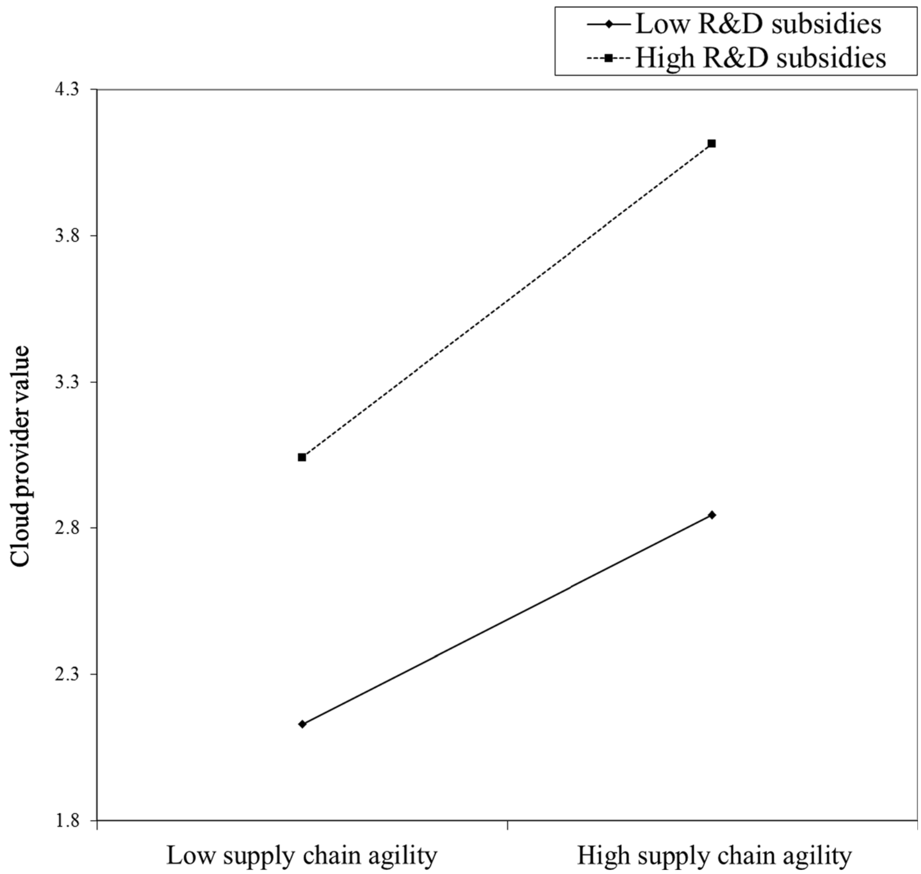


Fig. 4 The interactive effect of R&D subsidies on the positive relationship between supply chain agility and cloud provider value

subsidies in the process of information system flexible value generation.

5.2 Implication

Due to objective conditions, there is a certain limit and deficiencies in this study. The geographical distribution of questionnaires relative concentration of educated than the overall sample of respondents is high, ignoring regional differences for cloud-native flexible architecture there is recognition of the value effect. But overall, this research provides theoretical support and practical suggestions for public health machine learning software development enterprises on how to correctly adopt cloud-native.

(1) When building a cloud-native public health machine learning software, not only should pay attention to the direct agency agreement with the direct software implementer, but also whether the relevant agreement agreed with the internal organization and the third-party service provider should be paid attention to, such as internal project commitments, and able to support the provision of cloud services. Only through the establishment of the overall principal-agent relationship can it be possible to achieve flexible system response to emergency health events and ensure the reliability and availability of system software in emergencies.

(2) Public health machine learning software providers should pay attention to cloud-native architecture flexibility to support internal teams and third-party service providers when developing with cloud-native architecture. Especially in the case of public health emergencies, can the cloud-native architecture quickly add new modules to achieve wide compatibility with external systems, and at the same time achieve temporary multi-system multi-terminal connection? Only pay attention to the balance of the flexibility of its cloud-native architecture in the top-level design, and fully support the opening of internal teams and cooperation with external third-party service providers in emergencies, to ensure the prevention of public health incidents, and at the same time for the post-epidemic. The resumption of work and production provides effective support.

(3) When public health machine learning software provider's top-level design measures the flexibility of the cloud-native architecture, it should not only pay attention to its performance value but also its assistance value. Only when these two values are

fully considered can it be beneficial to scientifically design the cloud-native architecture and make it more economical. For example, when measuring platform performance, we not only pay attention to the external value it brings to providers, such as market expansion and cost reduction, but also pay attention to its internal value to internal information sharing and employee collaboration.

(4) For the personnel of Chinese enterprises in this survey, R & D subsidies have a significant effect on both the agility of integrated supply chain and the absorptive capacity of internal organizations. In particular, China is vigorously funding the new generation of information technology. Relevant institutions will further promote the generation of flexible value of public health machine learning platform based on cloud native by making rational use of relevant funding policies.

5.3 Limitation and future research

Although we have significantly extend the research on the relationship between cloud-native architecture flexibility and cloud provider value. There are some limitations in this study.

First, we discussed the impact of cloud on-premise architecture flexibility on cloud provider value, but the impact of cloud native architecture flexibility on the value of cloud providers needs further discussion, and in particular more research should be conducted to assess its long-term impact. Specifically, we can try to disaggregate cloud provider value into its two dimensions: performance value and assistance value and explore the different effect of cloud-native architecture flexibility on such two cloud provider value dimensions.

Second, our empirical results provide robust supports for the mediating effects of absorptive capacity and supply chain agility on the relationship between cloud-native architecture flexibility and cloud provider value. However, after controlling for the indirect effects of these two mediations, the direct effect of cloud-native architecture flexibility also is significant, which suggests that absorptive capacity and supply chain agility only partially mediate the relationship between cloud-native architecture flexibility and cloud provider value. This indicates that some other possible mechanism may be missing in the study. Further research should try to find possible additional mechanism to fill in this research gap, such as innovation, learning, and inter-function integration within the firm.

Third, our findings suggest that R&D subsidies enhance both the positive effect of supply chain agility and absorptive capacity on cloud provider value. These findings provide some new perspectives into the boundary condition of the effects of absorptive capacity and supply chain agility on the cloud provider value generation mechanism. Further research could also examine the some other possible moderations. For instance, we can further study the impact of environmental factors as moderating variables on implementation effects, such as market turbulence brought by COVID-19 and other emergencies, technological turbulence brought by new digital technologies, and policy adjustment brought by national computing nodes.

Fourth, the data of this study are mainly from the survey of relevant personnel of Chinese public health machinery learning platform based on cloud-native, which may limit the general representativeness of the results of this study in other industries or countries. However, as China is a leading country in the development of cloud computing and artificial intelligence industry, the empirical results of this study can reflect certain representativeness. Future research could have benefits when exploring this relationship in other countries which are different from China in many areas, such as politics, economics, and laws.

Fifth, the generalizability of the findings should be considered in light of our study's limitations because of the flaws cross-sectional survey data. Due to the difficulty for survey research to explore causal relationship, mostly we only hypothesize our research propositions as correlation argument, our findings are more suggestive than conclusive. Longitudinal studies would help clarify whether the effect of cloud-native architecture flexibility on cloud provider value would persist in the long run. Time-lagged data or field studies would also allow for a proper examination of potential reciprocal effects across these two variables.

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Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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