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Full Research Paper

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Abstract: Cloud computing, a new type of digital infrastructure, can provide the necessary computing power to develop artificial intelligence, enhance the Internet of Things and the Industrial Internet to support their infrastructure layers, and reduce costs and increase efficiency for organizations. However, there has been little adoption or use of cloud computing in China, and it remains unknown what factors influence the diffusion of cloud computing in the region. This study establishes econometric models based on institutional theory and empirically analyzes the impact of three actors, namely, governments, enterprises that adopt cloud computing, and cloud computing suppliers, on the diffusion of cloud ecosystem using relevant data from Shandong Province, China. The results indicate that these participants have varying types of influence on the breadth and depth of cloud ecosystem diffusion in the region through their institutional pressure. This research also put forward some practical implications for the diffusion of cloud computing in the region.

Keywords: Cloud computing; cloud ecosystem; technology diffusion; institutional theory

1. INTRODUCTION

Cloud computing releases organizations from the burdens associated with the construction of complicated information systems, enabling them to focus more on their core business functions, reducing their costs, and increasing their efficiency. The technical features and service modes of cloud computing can also promote the implementation of new technologies, such as artificial intelligence and the Internet of Things [1]. Thus, the numerous advantages that cloud computing brings are leading more and more organizations to consider adopting it.

The extant literature largely explores the factors that affect the adoption of cloud computing at the organization level, which provides guidance to enhance the adoption of cloud computing. These studies have largely focused on establishing the impact of the characteristics of enterprises and cloud computing on the adoption of cloud computing. For example, the adoption of cloud computing could be improved by obtaining top management support [2] and improving the security and privacy of the technology used [3]. However, previous research has not been able to explain the diffusion of cloud computing at the regional level. Most of them ignore the influence of cloud computing as infrastructure and ecosystem in the region and neglect other participants' influence, like suppliers and core enterprises.

Cloud computing is a type of infrastructure with strong externalities, unlike other technological innovations. It does not affect a single enterprise alone but radiates its influence over an entire region. The diffusion of cloud computing is a multi-agent innovation diffusion process, which requires both the services provided by a supplier and the active participation of others in the region, such as the government and core enterprises. Therefore, cloud computing ecosystem should be developed to explore the factors that affect the diffusion of cloud computing at a regional level, which has not been established by previous research. Theories of adoption and diffusion, such as Technology-Organization-Environment (TOE) Framework, Technology Acceptance Model

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(TAM), and Diffusion-of-Innovation (DOI), could partly explain environmental factors that affect the diffusion of cloud computing at the organizational level but cannot comprehensively explain the impact of the external environment on the diffusion of cloud computing ecosystem in the region. This study, thus, employs institutional theory as its theoretical basis because it is suitable for establishing the influence of the external environment on innovation diffusion.

Furthermore, there has generally been little adoption of cloud computing technology in China, especially in the northern region, and only a few core enterprises have seen in-depth use of them, due to the limitations of the levels of technological and economic development. As a typical representative of northern provinces, Shandong province is facing traditional challenges of economic transformation. Therefore, this study takes Shandong province as an example to explore the influence factors of the diffusion of the cloud ecosystem in the region.

This study explores the influence of government, core enterprises, and cloud computing suppliers on the diffusion of the cloud ecosystem in the region, using institutional theory and data from Chinese cloud computing enterprises to provide feasible suggestions for the promotion of the development of cloud ecosystems.

2. THEORETICAL BACKGROUND

2.1 Institutional theory

Institutional theory is a core theory of sociological institutionalism, first put forward by DiMaggio and Powell [4]. This perspective holds that organizations carry out certain behaviors to satisfy the requirements of government and industry to obtain legitimacy to evade environmental restrictions. Institutional theory is an important approach for effectively explaining technology adoption, especially for technologies influenced by external actors, other technological approaches, and general policies.

DiMaggio and Powell identify three types of institutional pressure: coercive, mimetic, and normative. Coercive pressure derives from formal and informal pressures exerted on organizations by other organizations upon which they are dependent and from institutional expectations. It mainly results from the requirements of other suppliers in the industry chain [5] and their supervision or from the government [6]. The government and industry associations greatly influence enterprises' adoption behavior, especially in developing countries [7]. For example, the Chinese government once forced enterprises to adopt accounting computerization to aid the normalization of financial and tax management. Moreover, extant literature has found that coercive pressure plays an important role in cloud computing adoption [8][9].

To avoid the adverse effects of the application of new technologies, organizations may observe and imitate enterprises in their region that have obtained legitimacy or competitive advantages to reduce risk, such behavior is influenced by mimetic pressure. It has been shown that mimetic pressure could promote the adoption of cloud computing [6], as can be seen with the example of ERP. Because the implementation of ERP is full of uncertainty, enterprises are inclined to imitate successful ERP implementers at a similar scale, in a similar line of business, or in the same region to reduce their chance of failure [10].

Normative pressure is associated with professionalization. Professionalization means that professional bodies in the field, such as suppliers, customers, and third-party organizations, establish the cognitive base and enable the occupational autonomy to define the conditions and methods of their work [4]. Further, this professionalization normalizes the behavior of the organizations that enter the field in the future through professionalization. Martins et al. [8] found that the normative rules for adopting and implementing cloud computing in the industry significantly influence the adoption of cloud computing with normative pressure.

This research explores the diffusion of cloud ecosystems within a region based on institutional theory. This approach entails a few characteristics: it assumes an institutional isomorphism that could reasonably explain convergence between organizations. Cloud computing is an infrastructure similar to the Internet that can affect the whole society [9]. So, with the growth of enterprises adopting cloud computing, a cloud ecosystem formed in the region, which at the same time developed isomorphisms. Second, as a theory used to explain organizational adoption behavior, the institutional theory is often used to explain the adoption of cloud computing in other contexts [6][8][11]. This is because whether an enterprise adopts cloud computing depends not only on its own internal influences but also on the external pressures exerted by other organizations in the region [8][12]. However, the extant literature largely uses institutional theory to explore the adoption of cloud computing at the organization level, while our research explores the impact of institutional pressure on cloud ecosystem diffusion at a regional level. Third, the influence of the government, core enterprises, and suppliers on the diffusion of the cloud ecosystem in the region can be explained through coercive, mimetic, and normative pressures in the way that these are assessed in institutional theory. This is another important reason for using institutional theory as our theoretical basis.

2.2 The application of institutional theory in the cloud ecosystem diffusion

The government, core enterprises, and suppliers affect the diffusion of a cloud ecosystem by means of their different institutional pressures. The government utilizes policies and fiscal subsidies to promote the diffusion of the cloud ecosystem and to guide the direction of its development [9]. For example, the government guides the development of the technology ecosystem by formulating its own strategies and policies, reduces the cost of technology implementation by providing fiscal subsidies, and stimulates the diffusion of a technology ecosystem by rewarding benchmark enterprises. The instructions of higher levels of government are transmitted to industries through lower levels. These bodies may formulate different policies to accomplish their goals, and this could exert coercive pressure on enterprises in the region. Apart from administrative measures, the government could also use market forces to promote the adoption of cloud computing. For example, in China, the State Council and the Ministry of Industry and Information Technology (MIIT) have proposed publicizing typical cases and successful adoptions of cloud computing, as well as recommending cloud benchmarking enterprises to promote the development of cloud computing. These regulations allow enterprises to study how benchmarking enterprises can realize information transformation and improve their production efficiency through cloud computing, which can be illustrated by mimetic pressure and normative pressure.

The influence of core enterprises on the cloud ecosystem could also be characterized as institutional pressure. When enterprises come together, industrial clusters are formed in which a large number of suppliers begin to produce and sell around a core enterprise. These core enterprises generally have a dominant capability, so they may prefer to adopt new technologies such as cloud computing early [13]. Other enterprises may be subject to mimetic pressure to imitate those successful core enterprises. Alternatively, some core enterprises may force their upstream and downstream suppliers to adopt their information system to facilitate logistics management, another form of coercive pressure. Furthermore, some core enterprises (e.g., Haier) may build cloud platforms that conform to the characteristics of the industry after cloud computing is implemented and may provide such a platform to other enterprises, such as the COSMO Plat built by Haier, which allows mass customization. For platform adopters, this type of empowerment may form coercive and normative pressure, while enterprises that do not have a restrictive relationship with core enterprises may experience mimetic pressure from the success of cloud platform developers.

As a provider of technology and services, a supplier is an important participant in an ecosystem and also provides an important impetus promoting the development of the business ecosystem [14]. Suppliers often publicize the advantages of cloud computing to improve enterprises' willingness to adopt cloud computing. Participants in the activities organized by suppliers generally report their participation improves their understanding of cloud computing. Therefore, besides the improvement to service capabilities, cloud computing suppliers could also impose mimetic pressure through market publicity activities to promote the diffusion of cloud ecosystems.

3. RESEARCH METHODOLOGY

3.1 Data

This study takes the county region as its sample unit, for the following reason. Ni [15] indicated that the industrial cluster in China takes counties as units, and there are often one or more core enterprises in a given cluster, enabling network effects. This affects the application of cloud computing, making it gradually form a cloud ecosystem. Therefore, the influence of core enterprises on the diffusion of a cloud ecosystem can be observed through the county region. Moreover, county administrative departments are grass-roots practitioners of policy implementation in China. The impact of policy on the diffusion of cloud ecosystems can be observed in the county region because the government distributes subsidies to enterprises through county finance departments. Therefore, we choose the county region as our sample unit.

This study acquires the data for 136 counties through the questionnaire data on the integration of information technology and industrialization of Shandong Province and statistical data from Shandong Province in relation to excellent enterprises adopting cloud computing, from which we obtained the subsidies invested to promote the adoption and use of cloud computing for each sample and information on the core enterprises and suppliers in each sample.

3.2 Research variables

To measure how these participants affect cloud ecosystem diffusion through institutional pressure more objectively, this study proposes variables and an integrated model of the diffusion of the cloud ecosystem according to the characteristics of each participant. Figure 1 illustrates the research model.

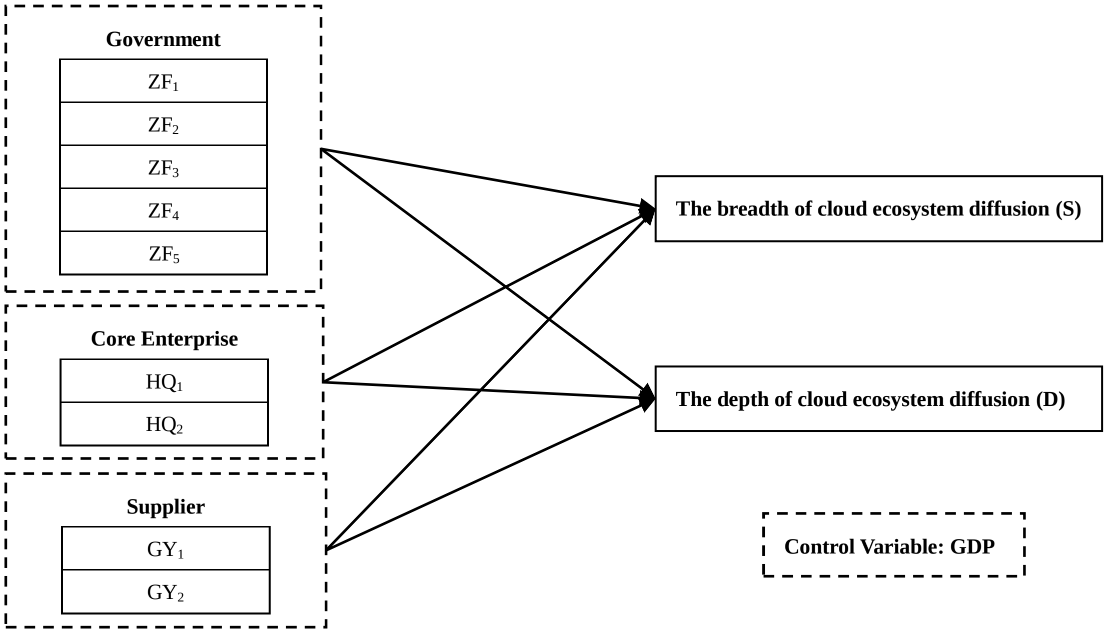

Figure 1. Research model

3.2.1 Government

The government fundamentally affects the diffusion of the cloud ecosystem through the use of three types of measures: fiscal subsidies, policy support, and publicity activities. This research proposes to investigate the amount of cloud service coupons (ZF_1) and the bonus of benchmarking enterprises (ZF_2) as variables to represent fiscal subsidies. Cloud service coupons are small, no more than 10000 RMB, while the bonus awarded to a benchmarking enterprise is large, with strict criteria. The cloud service coupons have largely been given to

SMEs, which can exchange coupons for fiscal subsidies. Due to the low standards, enterprises are easily able to obtain such subsidies. When SMEs in the region receive subsidies by adopting cloud computing, the herding effect leads other enterprises to adopt imitative behavior, which can accelerate the diffusion speed of the cloud ecosystem in the region. Thus, ZF_1 largely affects the diffusion of a cloud ecosystem through mimetic pressure.

The number of benchmarking enterprises in the region (ZF_3) is viewed as an independent variable for policy support. Benchmarking enterprises are chosen by the government according to criteria that are formulated in advance. Success in cloud computing by such an organization can form mimetic pressure in its region. Further, during their implementation of cloud computing, they can deepen their understanding of cloud computing and present a more better-grounded opinion, which can then be used by the government to revise its criteria. After being modified, the criteria can become more standardized and professional and can also, to a certain extent, reduce the difficulty of application, which could increase enterprises' enthusiasm for cloud computing. This means that larger numbers of benchmarking enterprises could also promote the diffusion of cloud computing through the addition of normative pressure.

Beyond providing fiscal subsidies, the government also produces publicity to advertise the benefits of cloud computing, such as reducing costs and improving efficiency. Such activities may stimulate enterprises to imitate other enterprises that have successfully adopted cloud computing to gain competitive advantages. Therefore, the number of publicity activities organized by the government (ZF_4), and the average number of participating enterprises in each (ZF_5) are proposed as non-fiscal subsidy variables.

3.2.2 Core enterprise

Core enterprises are those that have a dramatic influence on other enterprises in an industrial cluster. They are the leaders or the strategic core in the cluster and can affect the behavior or performance of other enterprises through their own methods, such as reducing or increasing the number of orders and advancing or postponing the time of payment.

The questionnaire provided by the MIIT divides the degree of implementation of cloud computing in an enterprise into three stages: initial construction stage, coverage of a single operational stage, and integration and innovation stage. We propose the number of integration and innovation enterprises (HQ_1), most of which are early adopters of cloud computing in the region as an independent variable. These are core enterprises and have great influence in their industrial cluster. The successful adoption of cloud computing by these enterprises can form a demonstration effect for other enterprises that have not taken up cloud computing, so HQ_1 influences the diffusion of the cloud ecosystem through mimetic pressure.

In addition, the number of enterprises that have formed a cloud platform (HQ_2) is another independent variable on the core enterprise level. On the one hand, enterprises that have formed a cloud platform are core enterprises with professional capability. The increase in the number of these enterprises can gradually standardize the use of cloud computing in the industry and form normative pressure. On the other hand, as core enterprises, they may force their partners to use their own cloud platforms, which represents coercive pressure.

3.2.3 Cloud computing supplier

The literature [16] indicates that regions or industries with a higher degree of industrial development and concentration tend to have a more extensive technological ecosystem, so we choose the number of cloud computing suppliers (GY_1) to represent the degree of development and concentration in the cloud computing industry in the region. The normative pressure caused by the increase of these professionals can affect other enterprises' attitudes and behaviors in the region. The competitive pressure caused by the increase in suppliers can stimulate them to enhance their service capabilities, which will directly influence enterprises' experience of using cloud computing and improve their willingness to use cloud computing [17].

Moreover, we choose the number of publicity activities organized by suppliers (GY_2) as an independent variable. Unlike the activities organized by the government, suppliers' activities are not mandatory, and they are more inclined to introduce their products from the perspective of the market. They choose to publicize the advantages of cloud computing and excellent cases to attract other enterprises, and this promotes mimetic pressure.

3.2.4 Cloud ecosystem

This study integrates the effects of factors on different dimensions of the cloud ecosystem, including breadth (S) and depth (D). The breadth of the diffusion of the cloud ecosystem refers to the popularity of cloud computing among the enterprises in the region, which is calculated by the proportion of enterprises adopting cloud computing among the total number of enterprises. The depth of cloud ecosystem diffusion refers to the understanding and application degree of cloud computing by the enterprises that have adopted cloud computing, which is calculated by the average proportion of cloud computing applications in business systems of enterprises in the region that have adopted cloud computing. The combination of the two dimensions can comprehensively reflect the development of the cloud ecosystem.

3.2.5 Control variable: GDP of each region

First, as the adoption of cloud computing requires investment in enterprises, the government tends to choose to pilot programs in more developed regions. Second, enterprises in developed regions tend to have access to more advanced thinking and better information, which can help enterprises encounter and adopt the relevant concepts of cloud computing at an earlier stage. Therefore, the diffusion of the cloud ecosystem may strongly correlate with GDP, which is why GDP has been chosen as a control variable to control the impact of different economic levels on this study.

Finally, from these considerations, two econometric models can be written, including the disturbance terms γ and ε, as follows:

$$S = \alpha_0 + \alpha_1 ZF_1 + \alpha_2 ZF_2 + \alpha_3 ZF_3 + \alpha_4 ZF_4 + \alpha_5 ZF_5 + \alpha_6 HQ_1 + \alpha_7 HQ_2 + \alpha_8 GY_1 + \alpha_9 GY_2 + \lambda_1 GDP + \varepsilon \quad (1)$$

$$D = \beta_0 + \beta_1 ZF_1 + \beta_2 ZF_2 + \beta_3 ZF_3 + \beta_4 ZF_4 + \beta_5 ZF_5 + \beta_6 HQ_1 + \beta_7 HQ_2 + \beta_8 GY_1 + \beta_9 GY_2 + \lambda_2 GDP + \gamma \quad (2)$$

4. RESULT

4.1 Analysis of descriptive statistics

Table 1 presents the characteristic variables of this investigation. The standard deviations ($STD_S = 3.32$, $STD_D = 5.13$) and the differences between the maximum and the minimum values for variables S and D indicate the degree of popularity of cloud computing in Shandong Province is not high in either sample, around the middle of the range for both. Compared to the degree of popularity of cloud computing, the difference in average business coverage rate for cloud computing between the samples is large, representing different depths of cloud computing diffusion.

The standard deviations for fiscal subsidy indicators ZF_1 and ZF_2 are relatively large, indicating that the financial budget for cloud computing development is quite different across regions, which may be related to the local level of economic development. For the non-fiscal subsidy indicators, according to the standard deviations of ZF_4 and ZF_5, although there is little difference in the number of publicity activities organized by the government in different regions, the number of participants in activities is obviously distinct in each region.

The number of integration and innovation enterprises (HQ_1) differs distinctly by region. The number of enterprises forming cloud platforms (HQ_2) is generally low, not more than 1 in most regions, and only 3 in the largest. Thus, we speculate that the impact of HQ_2 on the diffusion of the cloud ecosystem may be slight.

The value of the standard deviation for GY_1 is quite large. The area with the lowest value has only two small suppliers which are mainly product agents, while the largest region has 112 suppliers. One possible reason for this phenomenon is cloud computing technology requires greater talent and a higher economic level, so most suppliers will choose regions where they have access to more educational resources and greater economic vitality to set up companies.

In addition, the disparity in levels of economic development between regions within Shandong province is large, although Shandong is a province with a high level of economic development in China. The region with the highest GDP is nearly 50 times larger than that of the lowest region, so we expect that the impact of GDP on the diffusion of the cloud ecosystem may be significant and needs to be controlled.

Table 1. Variable summary statistics

Variable name	Definition	Min.	Max.	Mean	S.D.
ZF_1	The amount of cloud service coupons	836	5635	2287.37	23.11
ZF_2	The bonus of benchmarking enterprises	532	1962	769.86	16.62
ZF_3	The number of benchmarking enterprises	5	36	9.51	2.37
ZF_4	The number of publicity activities organized by the government	0	23	5.23	1.59
ZF_5	The average number of enterprises participants in an activity	0	533	156.36	8.38
HQ_1	The number of Integration and Innovation enterprises	123	657	236.45	8.68
HQ_2	The number of enterprises forming cloud platforms	0	3	0.23	0.47
GY_1	The number of suppliers of cloud computing	2	112	24.63	3.92
GY_2	The number of publicity activities organized by the supplier	5	19	8.03	1.52
S	The proportion of enterprises adopted cloud computing (%)	53.20	80.65	60.32	3.32
D	The proportion of cloud computing applications in the business system of enterprises (%)	9.30	60.62	36.23	5.13
GDP		77.80	3554.44	514.42	480.88

4.2 Statistical test

First, the White test is used to check for heteroscedasticity, a problem that often exists in cross-sectional data. The result indicates that Obs*R-squared = 57.12, which is less than the critical value when $\alpha = 0.05$. Therefore, the original hypothesis is accepted, indicating an absence of serious heteroscedasticity in the model.

Second, all values for the correlation coefficient between independent variables in Table 2 are less than 0.5, which indicates the absence of a serious multicollinearity problem in this study. And the correlation coefficient between independent and dependent variables almost larger than 0.5, confirming that they have a strong correlation and are suitable for regression tests.

The regression results are shown in Table 3, where Study 1 shows the influence of factors on the breadth of cloud ecosystem diffusion (S), and Study 2 shows the influence on the depth (D) of cloud ecosystem diffusion. According to the p values, the influence of each independent variable on the dependent variable are statistically significant, and the values of the F statistic indicate that the effects of all independent variables on the dependent variable are jointly significant in both models.

Table 2. The results of the correlation coefficients

	S	D	ZF_1	ZF_2	ZF_3	ZF_4	ZF_5	HQ_1	HQ_2	GY_1	GY_2
S	1.00										
D	0.82^{**}	1.00									
ZF_1	0.60^{**}	0.60^{**}	1.00								
ZF_2	0.56^{*}	0.71^{***}	0.33^{**}	1.00							
ZF_3	0.65^{**}	0.50^{**}	0.14^{*}	0.09^{**}	1.00						
ZF_4	0.67^{***}	0.80^{*}	0.21^{**}	0.47^{***}	0.65^{**}	1.00					

ZF₅	0.58***	0.48*	0.32**	0.46***	0.57**	0.35***	1.00				
HQ₁	0.58**	0.58**	0.26***	0.57***	0.57**	0.17***	0.28***	1.00			
HQ₂	0.43**	0.65***	0.43***	0.06*	0.44**	0.80**	0.63**	0.52**	1.00		
GY₁	0.66***	0.74***	0.25**	0.44***	0.30***	0.31***	0.41***	0.43***	0.57**	1.00	
GY₂	0.74**	0.66***	0.39***	0.16**	0.02*	0.09***	0.25***	0.31**	0.84***	0.29**	1.00

Table 3. The results of multiple regression

	Study 1		Study 2	
	α	p	β	p
ZF_1	0.896	0.000	0.851	0.000
ZF_2	0.223	0.008	0.274	0.000
ZF_3	0.468	0.001	0.563	0.001
ZF_4	0.667	0.001	0.727	0.000
ZF_5	0.698	0.001	0.668	0.000
HQ_1	0.332	0.006	0.338	0.009
HQ_2	0.246	0.032	0.365	0.05
GY_1	0.835	0.009	0.795	0.000
GY_2	0.394	0.041	0.453	0.036
GDP	1.56	0.000	2.63	0.000
Adjust R-square	42.30%		33.68%	
F	3.365		2.479	

4.3 Multiple regression analysis

In this study, the regression results are analyzed from the perspective of the three participants that influence the diffusion of the cloud ecosystem. The government influences the diffusion of the cloud ecosystem through fiscal subsidies, market publicity, and other means. The regression indicates that state subsidies (ZF_1 and ZF_2) have different effects on the breadth and depth of cloud ecosystem diffusion. The amount of cloud service coupons obviously influences the diffusion of cloud ecosystem in both dimensions (α_1=0.896, β_1=0.851), which could reduce the cost to enterprises of adopting cloud computing and make it easy for SMEs to obtain. However, few enterprises can meet the criteria for becoming benchmarking enterprises. Therefore, the bonus to benchmarking enterprises affects the diffusion of cloud ecology only negligibly (α_2=0.223, β_2=0.274). For enterprises that are deeply engaged in working with cloud computing, applying for the status of a benchmarking enterprise can stimulate them to deepen their commitment to cloud computing and bring them a huge bonus. For enterprises that have adopted cloud computing and whose demand for cloud computing is dispensable, although the bonus is attractive, the harsh criteria will damage their enthusiasm for the in-depth application to cloud computing. Enterprises that have not adopted cloud computing may be even further deterred. They will respond better to a small subsidy at first, such as cloud service coupons. Moreover, continuous increases in market publicity activities (ZF_4, α_4=0.667, β_4=0.727) and in the number of enterprises participating in activities (ZF_5, α_5=0.698, β_5=0.668) can significantly stimulate the diffusion of the cloud ecosystem, both in breadth and depth.

The core enterprise is another important participant in the diffusion of cloud ecosystems. Standardized regression coefficients show that the breadth of cloud ecosystem diffusion (S) is positively correlated with HQ_1 (α_6=0.332, β_6=0.338), a result that does not support previous research. According to Chen et al. [18], if half of all enterprises in a cluster adopt a technological innovation, the influence of the number of adopters on the diffusion of the innovation decreases steeply, and when the adopters exceed threshold, their influence on the diffusion of the innovation is almost zero. One important reason for our finding is that the development of the cloud ecosystem is at an early stage. After analyzing each sample, we found no region in which the number of integration and innovation enterprises is more than 50% of the number of all local enterprises. Therefore, it is reasonable to conclude that the HQ_1 positively influences the diffusion of the cloud ecosystem in this study.

Furthermore, it is worth noting that the number of benchmarking enterprises (ZF_3) strikingly impacts the diffusion of the cloud ecosystem, both in breadth and depth (α_3=0.468, β_3=0.563), while the number of enterprises forming cloud platforms (HQ_2) influences the cloud ecosystem only mildly (α_7=0.246, β_7=0.365). The reasons for this result are as follows: (1) according to the descriptive statistics, compared to the number of other enterprises, such as ZF_3, only a negligible number of enterprises are forming cloud ecosystem in the region, and (2) Cui and Shi [19] indicate that the coercive pressure of core enterprises on other suppliers is mainly concentrated within a single supply chain, while the proportion of enterprises in a certain industrial chain is not large over an entire region. For both reasons, although the number of enterprises forming cloud platforms is statistically significant, its impact on the diffusion of cloud ecosystem in the region is low.

The presence of suppliers of cloud computing is also an important factor for enhancing the diffusion of the cloud ecosystem in the region. On the one hand, the standardized coefficients of the regression indicate that the number of cloud computing suppliers (GY_1) significantly influences the diffusion of the cloud ecosystem (α_8=0.835, β_8=0.795). We speculate that an increase in the number of suppliers could prompt suppliers to enhance competitiveness and capability to occupy greater market share, which could improve the breadth and depth of the cloud ecosystem in the region. On the other hand, market publicity activities organized by suppliers (GY_2) only mildly influences the diffusion of the cloud ecosystem (α_9=0.394, β_9=0.453). The publicity is not mandatory, separating it from government publicity. Further, it is market-oriented and pays closer attention to whether enterprises can be transformed into new customers, so its scale is smaller, but the introduction of cloud computing is more in-depth and specific. Therefore, GY_2 has a greater impact on the depth of cloud ecosystem diffusion than on the breadth of cloud ecosystem diffusion.

5. CONTRIBUTION AND IMPLICATION

This study utilizes institutional theory to explore the factors that affect the diffusion of cloud computing in the region, and its results entail the following theoretical contributions and practical implications.

5.1 Theoretical contributions

First, this study supplements previous work on the construction of a cloud ecosystem. The literature mainly focuses on government policies and finds that the government can prompt the diffusion of cloud computing through state subsidies, while this study investigates other means, such as publicity activities organized by the government, that could also promote the development of a cloud ecosystem. In the construction of a cloud ecosystem, core enterprises play an important role. They could promote the diffusion of the cloud ecosystem in an industrial chain, as has been shown in the literature, but we find that they could also promote the diffusion of cloud computing within a region. We speculate that this is because core enterprises can produce atmospheres of mimetic pressure and normative pressure in a region through the demonstration effect, which could stimulate enterprises outside the industrial chain to adopt cloud computing and further promote the diffusion of the cloud ecosystem. The role of the cloud computing supplier is an important one, which has been neglected in previous studies. This study finds that the number of suppliers and the number of activities organized by suppliers in the region have a significant impact on the diffusion of the cloud ecosystem.

Second, this study enriches the research of technological innovation diffusion from a regional perspective. Enterprises in an industrial chain have strong dependency relations and their main business are closely related to each other, which is conducive to the diffusion of an innovation ecosystem. Therefore, previous research on innovation ecosystems has focused on the industrial chain. However, the cloud ecosystem is different from other innovation ecosystems. On the one hand, it has many service modes, and its different modes have different characteristics. On the other hand, as an infrastructure, it is not limited to a specific industrial chain. Thus, we explore the influencing factors of cloud ecosystem diffusion from a regional perspective. To a certain extent, the core enterprise factors represent a single industrial chain that extends only over a part of the region, while they also represent the impacts caused by different industrial chains. Factors such as the government and suppliers are often ignored by relevant research focusing on the industrial chain. This study brings them into the model to explore the diffusion of the cloud ecosystem in the region and expand the research level.

Third, cloud computing initially only affects single enterprise, but the results of field research show that the diffusion of cloud computing can rise to a higher regional level, and every enterprise in the region is affected by institutional pressures. Compared with other technological innovations, cloud computing has unique characteristics, such as its stronger service capacity and stronger externality, which have been ignored by previous studies of technological diffusion. Considering the influences of externality, core enterprises and suppliers are also included in this research, and the sources of externality are explained by institutional theory. The results confirm that these factors all have significant influences on the diffusion of the cloud ecosystem, which indicates that institutional pressure not only influences single enterprise and single industrial chain but also forms a regional atmosphere. Such an atmosphere may bring pressure on all enterprises in a region and stimulate the diffusion of a cloud ecosystem. Therefore, this study exhibits an innovative use of technological diffusion theory and institutional theory.

5.2 Practical implications

This study provides practical suggestions for the government to formulate policies that can be used to guide the development of the cloud ecosystem. In relation to the diffusion of the cloud ecosystem, one important safeguard measures put forward by the government is to increase state fiscal subsidies. In practice, however, when excessive subsidies go to some enterprises, other enterprises may adopt cloud computing blindly and even seek to gain subsidies by fraud, which will lead to limited subsidies being concentrated in the hands of a few enterprises, making the policy ineffective. However, if an indiscriminate subsidy method is adopted, which provides equal subsidies to all enterprises, the subsidies received by enterprises will be too small, which may lead many enterprises to give up applying subsidies and reduce their willingness to adopt cloud computing. In addition, the government will only rarely carry out other market-oriented measures to promote the diffusion of a cloud ecosystem, because its understanding of new technologies is not thorough. Although this investigation finds that some governments have begun to guide enterprises to adopt cloud computing through market publicity activities, the effect is not satisfactory. Some governments attach too much importance to the number of sessions and participants in publicity activities so that frequent activities are carried out and each activity is overcrowded. These activities increase the burden of the information departments in enterprises and greatly reduce the effectiveness of activities.

The results of this study can lead to recommendations for future government policies and measures. For fiscal subsidy measures, the government could adopt a graded subsidy, giving both large subsidies and general subsidies. For enterprises, even core enterprises, large subsidies are so attractive that they can form coercive pressure that is not based on administrative power. The government could utilize this coercive pressure to set higher standards. For example, only enterprises that implement R&D services, production control services, or even intelligent application services in cloud computing would be granted large subsidies, while other enterprises could receive general subsidies if they implement infrastructure cloud services or platform cloud services. This measure would not only enhance the enthusiasm of enterprises to adopt cloud computing but also prevent others from blindly adopting cloud computing or seeking to fraudulently receive subsidies. At the same time, this would deepen the use of cloud computing by enterprises. In addition, Breznitz et al. [20] found that venture capital could increase the number of early adopters of cloud services and deepen users' degree of application to cloud computing. We speculate that this may be because there are a series of uncertain risks in the application of new technologies, and the support of external funds can reduce the losses caused by risks. Thus, the government can encourage enterprises to adopt cloud computing by establishing an industry fund.

For non-fiscal subsidy measures, the results indicate that publicity activities can promote the diffusion of a cloud ecosystem. The number of such activities could deepen the application of cloud computing in enterprises, and the number of participants in them could affect the breadth of cloud ecosystem diffusion. Therefore, the government could make a targeted choice of whether to increase the number of activities or the number of participants when organizing publicity activities. If its purpose is to increase the breadth of diffusion of a cloud ecosystem, the number of participants in activities should be increased as much as possible. If the depth needs to be developed, the number of activities for specific enterprises can be increased.

The results of the impact of core enterprises on cloud ecosystem diffusion can provide practical references in two aspects. First, the results indicate that the increases of benchmarking enterprises in the region can prompt enterprises to adopt cloud computing, while the bonus of benchmarking enterprise influences the diffusion of cloud computing only slightly. Therefore, the government should focus on issuing more flexible and appropriate criteria for benchmarking enterprises instead of increasing the number of financial incentives that enterprises have little chance of obtaining. Core enterprises with strong capabilities should also strive to become benchmarking enterprises, which can not only enhance their core competitiveness but also promote the diffusion of a cloud ecosystem.

Second, although the results show that the number of enterprises that have built cloud platforms in the region has little impact on the diffusion of cloud ecosystems, this does not mean that enterprises do not need to establish cloud platforms belonging to their industries. We investigate such enterprises and find that once such platforms are empowered and available, they will obviously affect the application depth of cloud computing within the industrial chain. For example, many enterprises are empowered by the platforms provided by Handu. These enterprises have a comprehensive and in-depth application of cloud computing and can even realize the intelligent application of cloud computing at an early stage. Handu also built its own business ecosystem and enhanced its own competitiveness through its platform. Thus, if core enterprises can obtain financial support from the government and obtain R&D capability, building a cloud platform according to industry characteristics will be a reasonable choice.

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