Evolutionary Game for Enterprise Cloud Accounting Resource Sharing Behavior Based on the Cloud Sharing Platform

Hua-Ping Wu, *Member, IAENG,* Hui Li, Xiao-Lan Sun

Abstract— **In China, under the action plan of "Internet Plus," big data strategy, and sharing economy, the sharing behavior based on the cloud accounting resources sharing platform is also focused on. To save costs and obtain significant benefits from sharing, enterprises must share cloud accounting resources on the cloud sharing platform. Meanwhile, they influence each others sharing behavior. In this paper, to better solve the sharing problems, the sharing behaviors of participants are analyzed from the view of a demand-side enterprise. Furthermore, the basic assumptions and an evolutionary game model are proposed. Then, the processing of dynamic evolution and influencing factors of the sharing behaviors of cloud accounting resources are explored. Finally, the game equilibrium strategy and its stable state are obtained. The relevant suggestions are given from the perspective of the government, cloud platform, and supplier-side and demand-side enterprises themselves.**

Index Terms—**Cloud Sharing Platform, Sharing Behaviors, Evolutionary Game**

I. Introduction

IN the era of big data, the sharing economy penetrates deep into all aspects of life. The cloud accounting resources sharing has also become a future trend of development. Only 10 years ago, the Ministry of Finance promulgated "Guiding opinions on comprehensively promoting accounting informatization in China," the purpose of which was to promote the combination of information and achieve sharing of accounting resources so as to reduce costs. For example, many medium-sized and small enterprises can cut the cost through sharing cloud accounting software. The cloud accounting services are becoming increasingly popular. In 2018, the Huawei, with the theme of "Platform Power," shared how the "Platform +X+ Ecology" model could help enterprises accelerate their transformation. During the conference of "2018 Inspur World," the Inspur decided to establish the "China Open source industrial internet PaaS Union" with the collaborators, all kinds of technical teams and operators who provide SaaS services in the Inspur PaaS platform. To implement resources sharing among enterprises, the platform and the cloud need to be reconstructed[1]. It not only satisfies the sharing, but is also a win-win situation for participants. However, in the process of resource sharing, the behaviors of participants influence greatly the effect of sharing. Therefore, it is important that the behaviors of participants would be explored on the cloud sharing platform.

In recent years, Rahmam[2]proposed that the sharing economy carried out through the platform could attain the best allocation of resources and reduce the transaction costs. In the sharing process, the sharing software system becomes a key factor. Stangler[3]studied the platform economy model based on the internet and presented the internet platform economy considering the platform to connect different demand subjects and attain communication and trading. Zysman[4]solved the problem of platform manufacturing and deployment. Meanwhile, the accounting information sharing has been mentioned in a few papers. Liu[5]considered the accounting information sharing. However, it was limited to the internal system of enterprises.

Furthermore, if the accounting information is shared among enterprises, a game is going to happen. Here, the evolutionary game is applied to analyze the behavior of enterprises. Nowak[6]presented evolutionary game theory, which regards the process of changing group behavior as a dynamic system, and the game subject as a bounded rational man. It breaks through the limitations of the rational assumption of previous game theory and emphasizes the system dynamic equilibrium. Jensen[7]pointed out that when the strategies of limited strategy sets of individuals in a group are interacting, there will be a non-uniform random-matching evolutionary game. After an arbitrary match, the Nash equilibrium and evolutionary stable strategy (ESS) will appear. There would always be certain matching rules in group activities leading to a stable system. Here, the behavior of enterprises needs to be analyzed using the Nash equilibrium and evolutionary stable strategy in the processing of sharing accounting information on the cloud sharing platform.

Therefore, in this paper, the behavior of enterprise is explored using the cloud accounting resource sharing platform. Many key factors that affect the decision of enterprises are analyzed to find the equilibrium and stable strategy. This will promote the development of cloud sharing platforms and accelerate cloud accounting resource sharing optimization[8].

II. Problem Description

A. Cloud Sharing Platform

The cloud sharing platform is a virtual resource cloud pool. The platform is supported by a physical and a virtual resource layer to provide cloud services to demand-side and supply-side enterprises. The cloud sharing platform is

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H.P. Wu is with Accounting R&D Center, Chongqing University of Technology, Chongqing, 400054, China, e-mail: hpwu@cqut.edu.cn.

H. Li is with Accounting R&D Center, Chongqing University of Technology, Chongqing, 400054, China X.L. Sun is with Accounting R&D Center, Chongqing University of Technology, Chongqing, 400054, China.

shown in Figure 1. In addition to the basic functions of the platform, it also illustrates the functions of transaction and service. Meanwhile, the cloud platform itself also provides cloud services. Enterprises need to purchase cloud services and share cloud resources. The main purpose of building a cloud sharing platform is to offer cloud accounting services to enterprises and establish the bridge between providers and users[9]. It integrates all cloud resources into the platform in which users could promptly find what they need. Furthermore, it creates a win-win and mutually beneficial ecosystem of multiple parties. To efficiently promote cloud resource sharing, the cloud sharing platform owns a large number of suppliers and demanders, who constantly improve and optimize the platform. Finally, all of them benefit from the platform as much as possible.

B. Cloud Accounting Resource Sharing

The cloud accounting resources include the following five items: network, server, storage, applications, and services[10]. Besides those, cloud accounting resources based on a cloud sharing platform include four parts. The first is the information related to suppliers (e.g., the service types provided by suppliers and the overall evaluation of after-sales service). The second is the information related to the users (e.g., the demand of the users, estimated price). The third is the relevant information among enterprise users (e.g., the financial processing mode and decision-making information). The fourth is information among suppliers (e.g., technology-upgrading information, product and service price information, product and service differences). Consequently, the cloud accounting resources based on platform are as follows:

Network: Physical and virtual network

Server: A device that provides computing services

Storage: Storage device connected through the internet

Application: Software services provided by suppliers or platform

Services: Consultation provided by suppliers or platform

Information related to demanders: Financial processing mode, decision-making information, estimated purchase price, and so on

Information related to suppliers: Technology updated information, product and service price, and so on

C. Analysis of Cloud Accounting Resource Sharing Behavior

Chinas Ministry of Industry and Information Technology issued the guidelines for promoting the implementation of enterprise cloud service (2018-2020) in August 2018. The guidelines encourage enterprises to use cloud computing to accelerate the transformation of digitalization, networking, and intelligence, and promote the deep integration of the internet, big data, artificial intelligence, and the real economy. However, it required higher costs for most enterprises, especially small and medium-sized. The advantages of cloud accounting resource sharing could solve the problem. Its advantages are as follows: First, the demand-side enterprise can flexibly purchase cloud accounting resources based on actual business. Second, the cloud sharing platforms can help demand-side enterprises dynamically match the proper supplier-side enterprises. It is difficult for demand-side enterprises to choose suitable products and services for themselves among many supplier-side enterprises. Third, enterprises could share multiple kinds of information on the platform, such as the use of cloud accounting resources, after-sales service of supplier-side enterprise, and decision-making information that enterprises are willing to share. If enterprises share cloud accounting resources by each other, they will benefit from it.

However, enterprises may also consider the following factors before choosing cloud accounting resource sharing. The most critical problems are the risk from sharing, such as data insecurity, stability, and continuity, so that they hesitate to share cloud accounting resource. Moreover, the cloud platform services include providing cloud accounting resources, matching the supplier-side enterprise and demand-side enterprise, cloud consulting services, intelligent monitoring, and maintenance of cloud accounting resources. In the current platform, there is confusion due to lack of government supervision. Therefore, government supervision is necessary.

III. EVOLUTIONARY GAME MODEL

*A. **Assumptions***

For the above-mentioned reasons, the paper considers the strategic choice of the supplier-side enterprise and demand-side enterprise under the influence of the platform. Whether these enterprises will choose to share cloud accounting resources is a dynamic game process that keeps repeating. In the game process, both motives are driven by interests. Under the effect of mutual familiarity and imitation, they make a decision whether to share cloud accounting resources. The players in the game are all considered to be limitedly rational. With the continuous improvement of the construction of cloud sharing platform, they will make repeated strategic decisions in a continuously dynamic environment[11]. Therefore, based on the analysis of the enterprise cloud accounting resource sharing behavior, the following hypotheses are proposed[12].

Hypothesis 1: The strategic choices of the supplier-side (A) and demand-side enterprise (B) are both cloud accounting resource sharing, cloud accounting resource not sharing. If the enterprise chooses to share cloud accounting resources, it will get shared benefits and also pay a certain cost. If the enterprise chooses not to share cloud accounting resources, the supplier-side enterprise has no relevant interest relationship with the resource demand-side enterprise.

Hypothesis 2: The information resources obtained from the enterprise on the cloud platform can help the enterprise obtain shared revenue. These information resources can help enterprises adjust their strategic decisions and optimize financial processes. Shared revenue includes direct revenue and indirect revenue. Direct revenue is obtained by sharing cloud accounting resources between enterprises. It is mainly affected by the number of cloud accounting resource sharing $K_i(i = A, B)$ and resource conversion ability $V_i(i = A, B)$. Therefore, direct revenue could be expressed by K_iV_i. Indirect revenue is related to the services $S_i(i = A, B)$ obtained from the cloud sharing platform and the comprehensive quality of enterprise $P_i(i = A, B)$. Therefore, the indirect revenue of resource supplier-side and

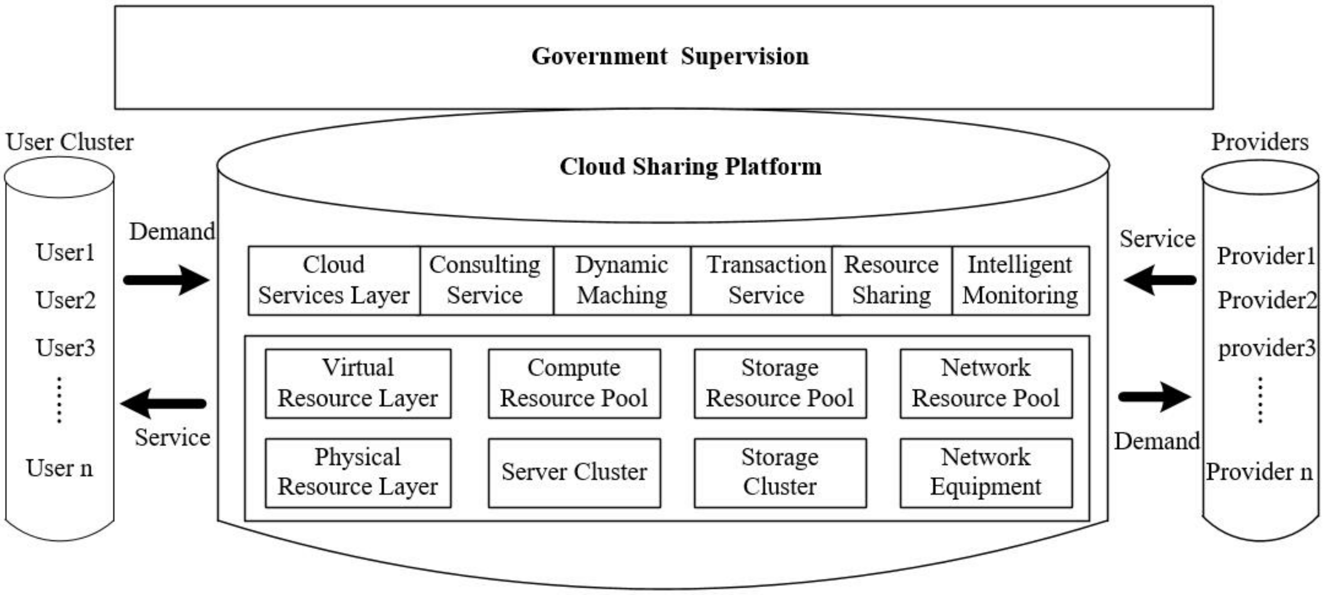

Fig. 1: Cloud sharing platform

demander-side enterprises will be expressed as $S_iP_i(i = A, B)$ $(S_{\mathrm{i}} > 0, P_i > 0)$. Generally speaking, most of the shared revenue is direct revenue. At the same time, the cloud sharing platform encourages resource supplier-side and demand-side enterprises to join the platform and share cloud accounting resources, providing a certain number of incentives for them. Here, R represents the incentive.

Hypothesis 3: Resource supplier-side and demand-side enterprises will pay for cloud accounting resource sharing. The cost includes not only economic and opportunity costs, but also shared risk costs. C represents the cost coefficient of cloud accounting shared resources selected by the enterprise (the coefficient includes risk factors, opportunity cost factors, etc.) $(0 < C < 1)$. Therefore, the sharing costs of enterprises are CK. At the same time, if the resource demand-side enterprise chooses not to share cloud accounting resources, but obtain the resources on the platform, the cost paid by the one will increase. The cost is expressed as ΔC.

Hypothesis 4: The probability of choosing cloud accounting resource sharing from the supplier-side and demand-side enterprise is, respectively, X and Y. Then, the probability of not sharing cloud accounting resources from them is, respectively, $1 - X$ and $1 - Y$ $(X \in [0, 1]; Y \in [0, 1])$, and all of them are functions of time.

The above variables explanations are shown as follows.

X: Probability of a supplier-side enterprise sharing resources.

K: The number of cloud accounting resource sharing.

S: Cloud platform services.

P: Comprehensive quality of enterprise.

Y: Probability of demand-side enterprise sharing resources.

V: The capacity of enterprise resource transformation.

ΔC: Obtain cloud accounting resource costs separately.

C: Cost and risk coefficient of cloud accounting shared.

R: Incentives provided by the platform for enterprises choosing to share resources.

T: The function of time.

B. *Return Matrix*

Game participants keep choosing whether to share cloud accounting resources until they find the optimal strategy and tend to stabilize. Based on the above assumptions, a cloud accounting resource sharing revenue matrix is constructed for the resource supplier-side enterprise and demand-side enterprise. It is presented in Table 1.

IV. Analysis of Evolutionary Game Model

The analysis of the game players selection is mainly based on the theory of evolutionary stability strategy. Namely, the replication dynamic equation of the game player $F(X)$ meets $F(X) = 0$ and first partial derivative $F'(X) < 0$. The mechanism is that the function has an anti-interference ability by means of monotonic decreasing. When the function deviates from the stable point, it can change in the opposite direction. This paper used the criteria for judging the evolutionary stability strategy (ESS) of local equilibrium points of evolutionary game systems proposed by Friedman[13]. It is that the Jacobian determinant of ESS is ¿zero, and the trace value of matrix is ¡zero.

A. *Replication Dynamic Equation Analysis*

Based on the revenue matrix of cloud accounting resource sharing behavior in Table 1, the replication dynamic equation is established to study the evolution dynamic rules among groups. The first step is to build the expected return function. The supplier-side enterprise adopts the revenue expectation function of the sharing strategy of a cloud accounting resource U_{A1}, the non-sharing strategy of cloud accounting resource U_{A2}, and the average revenue U_A as follows:

$U_{A1}{=}Y(K_BV_A{+}S_AP_A{+}R{-}C_AK_A){+}(1{-}Y)(S_AP_A{+} R - C_AK_A)$ (1)

$U_{A2} = Y(-\Delta C_A) + (1 - Y)(-\Delta C_A)$ (2)

TABLE I: Comparison of algorithms based on optimal solutions

		demand-side enterprises B	
		sharing (Y)	not sharing $(1-Y)$
supplier-side enterprises A	sharing (X)	$K_BV_A+S_AP_A+R-C_AK_A$ $K_AV_B+S_BP_B+R-C_BK_B$	$S_AP_A+R-C_AK_A$ $-\Delta C_B$
	not sharing $(1-X)$	$-\Delta C_A$ $S_BP_B+R-C_BK_B$	$-\Delta C_A$ $-\Delta C_B$

$U_A = XU_{A1} + (1-X)U_{A2}$ (3)

According to Equations (1) and (3), the replication dynamic equation of cloud accounting resource sharing behavior of resource supplier-side enterprise can be constructed:

$F(X) = \frac{d(X)}{d(T)} = X(U_{A1} - U_A) = X(1-X)(YK_BV_A + S_AP_A + R - C_AK_A - \Delta C_A)$ (4)

$F(X)$ represents the change rate of resource supplier-side enterprises selecting the sharing strategy of a cloud accounting resource over time. For resource supplier-side enterprise, when Y satisfies the condition of $Y = \frac{\Delta C_A + C_AK_A + R - S_AP_A}{K_BV_A}$, $F(X)$ will get the following result of $F(X) = 0$. It means $F(X)$ is stable for all X.

When Y satisfies the condition of $Y \neq \frac{\Delta C_A + C_AK_A + R - S_AP_A}{K_BV_A}$, $X = 0$ and $X = 1$ are stable states. When X satisfies the condition of $X = 0$, ESS represents that resource supplier-side enterprise chooses not to share cloud accounting resources. When X satisfies the condition of $X - 1$, ESS means that resource supplier-side enterprise chooses to share cloud accounting resources. Take the derivative of $F(X)$, and the following equation will be obtained: $F(X)' = (1-2X)(YK_BV_A + S_AP_A + R - C_AK_A - \Delta C_A)$. Now, there are two possible values of Y:

When Y satisfies the condition of $Y < \frac{\Delta C_A + C_AK_A + R - S_AP_A}{K_BV_A}$, the following two inequalities will be obtained: $F(X)'|_{X=0} < 0$ and $F(X)'|_{X=1} > 0$. At this point, $X = 0$ is the evolutionary stability strategy. Y will continue to decrease, and X will continue to decrease too, indicating that it is the best strategy for resource supplier-side enterprise to choose not sharing.

When Y satisfies the condition of $Y > \frac{\Delta C_A + C_AK_A + R - S_AP_A}{K_BV_A}$, the following two inequalities will be obtained: $F(X)'|_{X=0} > 0$ and $F(X)'|_{X=1} < 0$. At this point, $X = 1$ is the evolutionary stability strategy. Y will continue to increase, and X will also continue to increase, indicating that the best strategy for resource supplier-side enterprise is to choose sharing.

Similarly, we can obtain the replication dynamic equation of resource demand-side enterprise:

$F(Y) = \frac{d(Y)}{d(T)} = Y(U_{B1} - U_B) = Y(1-Y)(XK_AV_B + S_BP_B + R - C_BK_B - \Delta C_B)$ (5)

$F(Y)$ represents the change rate of the resource demand-side enterprises selection of sharing strategy cloud accounting resource over time. When X satisfies the condition of $X = \frac{\Delta C_B + C_BK_B + R - S_BP_B}{K_AV_B}$, it means that $F(Y)$ is a stable state for all Y. When X satisfies the condition of $X \neq \frac{\Delta C_B + C_BK_B + R - S_BP_B}{K_AV_B}$, $Y = 0$ and $Y = 1$ are stable states. Take the derivative with respect to $F(Y)$, and the following equation will be obtained: $F(Y)' = (1-2Y)(XK_AV_B + S_BP_B + R - C_BK_B - \Delta C_B)$. Now, there are two possible values of X.

When X satisfies the condition of $X < \frac{\Delta C_B + C_BK_B + R - S_BP_B}{K_AV_B}$, the following two inequalities will be obtained: $F(Y)'|_{Y=0} < 0$ and $F(Y)'|_{Y=1} > 0$. At this point, $Y = 0$ is the evolutionary stability strategy, X will continue to decrease, and Y will also continue to decrease, indicating that the best strategy for the resource demand-side enterprise is to choose not sharing.

When X satisfies the condition of $X > \frac{\Delta C_B + C_BK_B + R - S_BP_B}{K_AV_B}$, then the following two inequalities will be obtained: $F(Y)'|_{Y=0} > 0$ and $F(Y)'|_{Y=1} < 0$. At this point, $Y = 1$ is the evolutionary stability strategy, X will continue to increase, and Y will also continue to increase. Thus, the best strategy for the resource demand-side enterprise is to choose sharing.

B. *Stability Analysis of Dynamic Replication System*

From the differential equations (4) and (5), a two-dimensional dynamic system can be obtained: $\frac{d(X)}{d(T)} = X(1-X)(YK_BV_A + S_AP_A + R - C_AK_A - \Delta C_A)$, $\frac{d(Y)}{d(T)} = Y(1-Y)(XK_AV_B + S_BP_B + R - C_BK_B - \Delta C_B)$.

Five local equilibrium points of the cloud accounting resource sharing game can be obtained by replicating the dynamic equation between the supplier-side enterprise and demand-side enterprise: $O(0,0)$, $E(0,1)$, $F(1,0)$, $G(1,1)$, $H\left(Y = \frac{\Delta C_A + C_AK_A - R - S_AP_A}{K_BV_A}, X = \frac{\Delta C_B + C_BK_B - R - S_BS_B}{K_AV_B}\right)$. The five equilibrium points constitute the game solution domain of cloud accounting resource sharing behavior. X and Y satisfy the conditions: $\{X, Y | 0 \leq X \leq 1, 0 \leq Y \leq 1\}$. Next, the stability of the five local equilibrium points can be derived using the Jacobian matrix:

$J = \begin{bmatrix} \frac{\partial F(X)}{\partial X} & \frac{\partial F(X)}{\partial Y} \\ \frac{\partial F(Y)}{\partial X} & \frac{\partial F(Y)}{\partial Y} \end{bmatrix}$, in J,

$\frac{\partial F(X)}{\partial X} = (1-2X)(YK_BV_A + S_AP_A + R - C_AK_A - \Delta C_A)$,

$\frac{\partial F(Y)}{\partial Y} = (1-2Y)(XK_AV_B + S_BP_B + R - C_BK_B - \Delta C_B$,

$\frac{\partial F(X)}{\partial Y} = X(1-X)K_BV$,

$\frac{\partial F(Y)}{\partial X} = Y(1-Y)K_AV_B$.

At this point, the determinant $\det(J)$ and trace $tr(J)$ of the Jacobian matrix are used to determine the stability of the five equilibrium points of the game model, so as to find out the stability points and obtain the ESS. When the $\det(J)$ and $tr(J)$ satisfy the conditions, $\det(J) > 0$ and $tr(J) < 0$, the equilibrium point is the stability point. Put the values of the five local equilibrium points into (6) to obtain the specific values of the stable state of them. This is presented in Table 2.

TABLE II: Specific values of each stable state

The equilibrium point	$\frac{\partial F(X)}{\partial X}$	$\frac{\partial F(X)}{\partial Y}$	$\frac{\partial F(Y)}{\partial X}$	$\frac{\partial F(Y)}{\partial Y}$
O	$S_AP_A+R-C_AK_A-\Delta C_A$	0	0	$S_BP_B+R-C_BK_B-\Delta C_B$
E	$K_BV_A+S_AP_A+R-C_AK_A-\Delta C_A$	0	0	$-(S_BP_B+R-C_BK_B-\Delta C_B)$
F	$-(S_AP_A+R-C_AK_A-\Delta C_A)$	0	0	$K_AV_B+S_BP_B+R-C_BK_B-\Delta C_B$
G	$-(K_BV_A+S_AP_A+R-C_AK_A-\Delta C_A)$	0	0	$-(K_AV_B+S_BP_B+R-C_BK_B-\Delta C_B)$
H	0	Y_1	X_1	0

TABLE III: The stability analysis

The equilibrium point		$O(0,0)$	$E(0,1)$	$F(1,0)$	$G(1,1)$
	Determinant notation	+	-	-	+
$M_A>0, M_B>0$	Trace symbol	+	uncertainty	uncertainty	-
$N_A>0, N_B>0$	Stability	instability	saddle point	saddle point	ESS
	Determinant notation	-	-	+	+
$M_A<0, M_B>0$	Trace symbol	uncertainty	uncertainty	+	-
$N_A>0, N_B>0$	Stability	saddle point	saddle point	instability	ESS
	Determinant notation	+	+	+	+
$M_A<0, M_B<0$	Trace symbol	-	uncertainty	+	-
$N_A>0, N_B>0$	Stability	ESS	saddle point	instability	ESS
	Determinant notation	-	+	-	+
$M_A>0, M_B<0$	Trace symbol	uncertainty	+	uncertainty	-
$N_A>0, N_B>0$	Stability	saddle point	instability	saddle point	ESS
	Determinant notation	-	+	+	-
$M_A>0, M_B<0$	Trace symbol	uncertainty	+	-	uncertainty
$N_A>0, N_B<0$	Stability	saddle point	instability	ESS	saddle point
	Determinant notation	+	+	-	-
$M_A<0, M_B<0$	Trace symbol	-	+	-	uncertainty
$N_A>0, N_B<0$	Stability	ESS	instability	instability	saddle point
	Determinant notation	+	-	-	+
$M_A<0, M_B<0$	Trace symbol	-	uncertainty	uncertainty	+
$N_A<0, N_B<0$	Stability	ESS	saddle point	saddle point	instability
	Determinant notation	+	-	+	-
$M_A<0, M_B<0$	Trace symbol	-	uncertainty	+	uncertainty
$N_A<0, N_B>0$	Stability	ESS	saddle point	instability	saddle point
	Determinant notation	-	+	+	-
$M_A<0, M_B>0$	Trace symbol	uncertainty	-	+	uncertainty
$N_A<0, N_B>0$	Stability	saddle point	ESS	instability	saddle point

Table 2 indicates that the trace of the point H is constant to zero, so it cannot be a stable point. Thus, the stability of the four points: O, E, F,and G can be discussed. This paper supposes $S_AP_A+R-C_AK_A-\Delta C_A=M_A$, $S_BP_B+R-C_BK_B-\Delta C_B=M_B$, $K_BV_A+S_AP_A+R-C_AK_A-\Delta C_A=N_A$, $K_AV_B+S_BP_B+R-C_BK_B-\Delta C_B=N_B$. Because of $N_i\geq M_i$. There are nine random matching strategies for the four equilibrium points. The stability analysis of each equilibrium point in different situations is shown in Table 3.

The above analysis of the stability of the evolutionary gameshows that the enterprise's behavior strategies are closely related to factors such as shared revenue and risk cost, which affect the choice of enterprise behavior strategy. The stable strategies of cloud accounting resource sharing have the following possibilities.

First, when the following conditions are met at the same time: $\begin{cases} S_AP_A+R-C_AK_A-\Delta C_A<0 \\ S_BP_B+R-C_BK_B-\Delta C_B<0 \end{cases}$, the evolutionary stability strategy of the system is $(0,0)$. It means when the indirect benefits are less than the sharing costs and risks, then both resource supplier-side and demand-side enterprise adopt the strategy of not sharing cloud accounting resources.

Second, when the following conditions are met at the same time: $\begin{cases} K_BV_A+S_AP_A+R-C_AK_A-\Delta C_A>0 \\ K_AV_B+S_BP_B+R-C_BK_B-\Delta C_B>0 \end{cases}$, the evolutionary stability strategy of the system is $(1,1)$. In other words, when the sharing benefit is greater than the sharing cost and risk, both resource supplier-side and demand-side enterprise adopt the strategy of sharing cloud accounting resources.

Third, when the following conditions are met at the same time: $\begin{cases} S_AP_A + R - C_AK_A - \Delta C_A < 0 \\ S_BP_B + R - C_BK_B - \Delta C_B > 0 \\ K_BV_A + S_AP_A + R - C_AK_A - \Delta C_A < 0 \\ K_AV_B + S_BP_B + R - C_BK_B - \Delta C_B > 0 \end{cases}$ or $\begin{cases} S_AP_A + R - C_AK_A - \Delta C_A > 0 \\ S_BP_B + R - C_BK_B - \Delta C_B < 0 \\ K_BV_A + S_AP_A + R - C_AK_A - \Delta C_A > 0 \\ K_AV_B + S_BP_B + R - C_BK_B - \Delta C_B < 0 \end{cases}$, the system's evolutionary stability strategy is $(0,1)$ or $(1,0)$. When the difference between one party's shared revenue and cost is significantly greater than that of other party participants, the other party will give up the cloud accounting resource sharing strategy. However, these two kinds of stability points can be only the stable states that exist in theory and have no meaning in practice.

Fourth, there is a relatively special state. When the following conditions are met at the same time: $\begin{cases} S_AP_A + R - C_AK_A - \Delta C_A < 0 \\ S_BP_B + R - C_BK_B - \Delta C_B < 0 \\ K_BV_A + S_AP_A + R - C_AK_A - \Delta C_A > 0 \\ K_AV_B + S_BP_B + R - C_BK_B - \Delta C_B > 0 \end{cases}$, there are two evolutionary stability strategies $(0,0)$ and $(1,1)$. In addition, the specific analysis of situation at this time is as follows.

From the data in Table 3, $(0,0)$ and $(1,1)$ are the two stable points of the dynamic system, corresponding to the game strategy choices (not sharing cloud accounting resource, not sharing cloud accounting resource) and (cloud accounting resource sharing, cloud accounting resource sharing). $(0,1)$ and $(1,0)$ are the two unstable points of the system, and $\left(\frac{\Delta C_A + C_AK_A - R - S_AP_A}{K_BV_A}, \frac{\Delta C_B + C_BK_B - R - S_BP_B}{K_AV_B}\right)$ is the saddle point of the system. The two unstable points, the saddle point, and the two stable points in the system jointly construct regions OFHE and GFHE. Here, when the initial state of the game is in the regional OFHE, the system will converge to $(0,0)$ points, and both parties will eventually choose the strategy of "not sharing cloud accounting resources." When the initial state of the game is in the regional GFHE, the system will converge to $(1,1)$, and both parties finally chose the "sharing cloud accounting resource" strategy. Therefore, the final strategy of two parties is closely related to the initial state of the game. In addition, the size of the two areas affects the result. According to the geometric profile, the larger the area of the OFHE, the higher the probability that the two parties will eventually adopt the strategy $(0,0)$. Similarly, the larger the GFHE area, the greater the probability that both parties will eventually take the strategy $(1,1)$. The corresponding evolution phase diagram is shown in Figure 2.

V. Evolution Factor Analysis

According to the above analysis, the result of evolution is related to the area of the regional OFHE and GFHE. The larger the area of the regional OFHE, the greater the probability that both parties will not share cloud accounting resources. Conversely, the larger the area of the regional GFHE, the greater the probability that the two parties will share cloud accounting resources. The area of the regional OFHE can be expressed as follows:

$$S = \frac{1}{2}\left(\frac{\Delta C_A + C_AK_A - R - S_AP_A}{K_BV_A} + \frac{\Delta C_B + C_BK_B - R - S_BP_B}{K_AV_B}\right)$$

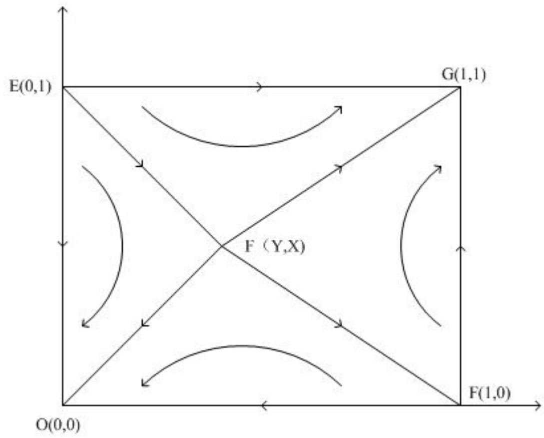

Fig. 2: Evolutionary phase diagram

(1) The impact of platform incentive R on the evolution process. The area of regional OFHE is used to derive the platform incentive R, and we can get: $\frac{\partial(S)}{\partial(R)} = -\frac{1}{2}\left(\frac{1}{K_BV_A} + \frac{1}{K_AV_B}\right) < 0$. From the derivative function, it can be seen that the area of OFHE is a monotonically decreasing function of platform excitation R. As the platform excitation R increases, the area of regional OFHE decreases accordingly. That is, when the platform's incentive R for the resource-supplier-side enterprise and demand-side enterprise to join the platform becomes larger, the area of the regional OFHE decreases, while the area of the regional GFHE increases in reverse. Then the probability the two parties choosing to share cloud accounting resources will increase accordingly, so the possibility that the system will evolve to $(1,1)$ also increases. Therefore, the incentives appropriately increased from platform can effectively promote the enthusiasm of participants, so that they will eventually evolve to the state of (sharing cloud accounting resource, sharing cloud accounting resource).

(2) The impact of direct income KV on the evolution process. Derived from the direct income KV in the OFHE area of the region, the following is obtained: $\frac{\partial(S)}{\partial(KV)} = -\frac{1}{2}\left(\frac{\Delta C_A + C_AK_A - R - S_AP_A}{(K_BV_A)^2} + \frac{\Delta C_B + C_BK_B - R - S_BP_B}{(K_AV_B)^2}\right)$. In this derivative function, $\frac{1}{(KV)^2} > 0$. For $\Delta C + CK - R - SP$, the indirect revenue is only a small part of the total revenue, and the value of platform incentive R is small, so $\Delta C + CK - R - SP > 0$ can be obtained. Finally, $\frac{\partial(S)}{\partial(KV)} < 0$ can be obtained. Then the area of regional OFHE is a monotonous decreasing function of direct revenue KV. With the increase of direct revenue KV, the area of regional OFHE decreases, while the area of the regional GFHE increases in the opposite direction. The above changes will eventually lead to the evolution of the stable state of the game in one direction (sharing cloud accounting resource, sharing cloud accounting resource). Therefore, the direct revenue increasing can directly promote the sharing cloud accounting resources. At the same time, the direct income is closely related to the number of resource sharing K and the ability of resource conversion V. Once the enterprise joins the cloud sharing platform for sharing cloud accounting resource, the number of resources it can obtain or share will be greatly improved. It not only promotes the direct

revenue increase, but also indirectly promotes an increase in the number of shared resources between enterprises. Thus, it will form a virtuous circle on the cloud resource sharing platform and will be an inevitable trend of sharing cloud accounting resource among enterprises. In the case of the number of shared and acquired resources increasing, enterprises will also gradually improve the capability of converting resources to improve the efficiency of integrating resources, which will in turn increase the direct income of the enterprise.

(3) The impact of sharing cost CK and the cost of acquiring cloud accounting resources separately ΔC on the evolution process. The area of regional OFHE takes the derivative of the sharing cost CK, and the cost of acquiring cloud accounting resources separately ΔC, $\frac{\partial(S)}{\partial(CK+\Delta C)} = \frac{1}{2}\left(\frac{1}{K_BV_A} + \frac{1}{K_AV_B}\right) > 0$ is obtained. Then the area of regional OFHE is a monotonically increasing function of cost. As the cost increases, the regional OFHE area will also increase. At this time, the two parties of the game will eventually evolve to a stable state (not sharing cloud accounting resources, not sharing cloud accounting resources). Therefore, reducing sharing costs through technical improvements is also an effective way to attract enterprises to join the cloud sharing platform.

(4) The impact of indirect revenue SP on the evolution process. The area of regional OFHE takes the derivative of the indirect revenue SP. $\frac{\partial(S)}{\partial(SP)} = -\frac{1}{2}\left(\frac{1}{K_BV_A} + \frac{1}{K_AV_B}\right) < 0$ is obtained. Then, the area of regional OFHE is a monotonous decreasing function of indirect cost SP. The increase of indirect revenue SP will cause the area of regional OFHE decrease and the area of regional GFHE increase in reverse. The system eventually evolves to a stable state (sharing cloud accounting resource, sharing cloud accounting resource). At the same time, indirect revenue is directly related to platform services S and the overall quality of the company's internal staff P. Improving the service capabilities of the platform can provide resource suppliers and demanders with a better user experience. Furthermore, the improvement of the overall quality of personnel within the enterprise can improve the efficiency of resource processing and reduce the unnecessary waste of resources. Therefore, improving the service capabilities of the platform and the overall quality of staff can promote the sharing of cloud accounting resources.

VI. Conclusions

From the perspective of game theory, this paper analyzes the cloud accounting resources sharing behavior of enterprises. A game model based on the cloud sharing platform is established. Moreover, the evolution process and related influencing factors of cloud accounting resource sharing behavior are explored. The results show that corporate strategy selection is mainly affected by the shared benefits and costs. To adapt to the development trend of sharing economy and promote the development of cloud sharing platform, the following suggestions are proposed from the aspects of the government, cloud platform, and resource supplier-side and demand-side enterprises.

(1) The government should strengthen the supervision to cloud sharing platform[14]. The evolutionary game stability analysis points that cloud platform services have a great impact on the strategy selection of sharing cloud accounting resource from enterprises. Furthermore, the governments supervision helps the platform regulate its services. At present, the virtual online trading environment and resource sharing system are relatively weak, which may easily lead to problems pertaining to sharing security. In this case, strengthening the government supervision mechanism is an effective measure to avoid sharing risks.

(2) The cloud sharing platform should improve service quality. The evolutionary game results show that cloud platform services are positively correlated with whether enterprises choose cloud accounting resource sharing strategy. Therefore, improving the service quality of cloud platform can promote cloud accounting resource sharing.

(3) The resource supplier-side enterprise should guarantee the products and services they provide. To promote the development of a cloud accounting resource sharing system, cloud accounting resource supplier-side enterprise needs to ensure the quality of their products and services forever. At the same time, the supplier-side enterprise should ensure a good service quality.

(4) The resource demand-side enterprise should improve the comprehensive quality of employees. The emergence of the new generation of information technology challenges the professional quality of accountants. If a demand-side enterprise chooses cloud accounting resource sharing, they will need employees to know enough about accounting resource sharing based on the cloud sharing platform. The game results show that the comprehensive quality of personnel is also positively correlated with the demand-side enterprise decision making. Therefore, it is necessary not only to examine the applicants financial knowledge, but also to investigate the information-related knowledge.

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