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Research Article

Research on the Informatization Construction and Development Mode of Internal Control in Colleges and Universities Based on Game Model

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With the advancement of information technology, the informatization construction of internal control has evolved into crucial fundamental support for the construction of internal control in colleges and universities. The informatization construction of internal control is a systematic project of which the selection of software development mode is the key link. In this paper, a detailed analysis is carried out on the equilibrium strategy of the two parties in the game between the informatization construction department of internal control in colleges and universities as well as software development companies by establishing a game model and a software maintenance risk management model for both sides, in order to probe into the selection of the software development mode in colleges and universities. The model test and case study prove that the fully commissioned development mode is the optimal mode for the informatization construction of internal control in colleges and universities, and relevant suggestions are made. This research has provided sufficient theoretical support for the informatization construction of internal control in colleges and universities.

1. Introduction

In 2012, the Ministry of Finance issued the "Regulations on Internal Control of Administrative Institutions (Trial)" to carry out the construction of internal control of administrative institutions nationwide. The Regulations mentioned that "Units should make full use of modern scientific and technological means to strengthen internal control. Centralized management by specialized departments should be implemented for the construction of information systems, and economic activities and their internal control processes should be embedded in the unit's information system to diminish or eliminate human manipulation factors and protect information security [1]." In 2015, the Ministry of Finance's "Guiding Opinions on Comprehensively Promoting the Construction of Internal Control in Administrative Institutions" emphasized that "the principal person in charge of a unit should make full use of information technology to organize and promote the construction of internal control of the unit, and assume leadership responsibility for the effectiveness of establishing and implementing internal control [2]". In 2016, the Ministry of Education also issued "Guidelines for Internal Control of Colleges and Universities Directly Under the Ministry of Education (Trial)" (hereinafter referred to as "Guidelines for Internal Control"), to initiate the construction of internal control in colleges and universities, requiring colleges and universities to establish a reasonable, comprehensive, and effective internal control system to regulate their daily economic activities. The Guidelines also put forward the requirements of "informatization management construction of internal control of economic activities [3]." The above documents emphasize the importance of internal control informatization.

With the all-around development of information technology, economic and business information systems have been deployed to most colleges and universities. Despite the rapid advancement of informatization in colleges and

universities, the construction and management of internal control informatization are still in their infancy. For this reason, how to implement internal control informatization is a major issue commonly faced by colleges and universities. Besides, the informatization construction of internal control, as a systematic project, needs to be implemented in accordance with standardized implementation steps under the guidance of scientific methods, in which the selection of software development mode is the key link. In this paper, based on the game theory, a detailed analysis is carried out on the equilibrium strategy of the two parties in the game between the centralized management department of internal control informatization in colleges and universities as well as software development companies by establishing a game model and a software maintenance risk management model of the selected model for both sides. Based on the research results, the fully commissioned development mode is the optimal mode for the informatization construction of internal control in colleges and universities, and relevant suggestions are made.

2. Literature Review

Research on the internal control informatization was carried out in a relatively early period of time abroad. Popescu et al. [4] believed that the internal management and control system of public entities includes three objectives: the effectiveness and efficiency of operations, the reliability of internal and external information, and the compliance with relevant laws, regulations, and internal policies. The implementation and development of the internal control system can be promoted by developing and updating the internal control system. Michelle [5] conducted a case study on the internal control informatization of a large enterprise. Based on the informatization of the management process of internal control, the enterprise transferred the original internal control process to the internal information management system through control review and risk nodes, which not only improved the operating efficiency of the internal process but also effectively elevated the level of internal control and management of the enterprise. Encouraged by the success of this research, an increasing number of companies have attempted to implement internal control informatization. Domestic research on internal control informatization started relatively late, most of which explored the framework of building internal control information systems by promoting the development of theory through practice. Tang et al. [6] contended that from the practice of unit construction, the implementation progress and prevalence of internal control informatization has become major factors of verifying the design and implementation effect of the internal control system. Peng [7] analyzed the problems in the informatization of economic activities in Chinese universities, such as financial management, asset management, procurement management, and contract management from the perspective of internal control, and explored the establishment of an information management platform for economic activities based on business process reengineering under the background of internal control construction in universities. He also proposed to set up a platform with a view to establishing a reasonable, comprehensive, and effective internal control system within colleges and universities by means of information technology to regulate the daily economic activities of colleges and universities, so as to ensure the legal compliance of economic activities, the safety and effective use of assets, and the improvement of financial assets management in colleges and universities. Zhang [8] proposed to build a new ecosystem of informatization internal control from three aspects, namely the application of informatization big data, IT governance concept, and business process reengineering, which is conducive to implementing the internal control of colleges and universities and giving full play to the monitoring role of internal control in the development and financial operation of colleges and universities.

Many domestic departments tend to select the development mode based on the experience of leaders and information technology-related personnel, which lacks objectivity and scientificity. Li [9] proposed to select the most suitable software development mode for six different types of enterprises by means of the AHP method and Expert Choice software from a quantitative perspective. Xiang (2014) et al. [10] applied the analytic hierarchy process (AHP) to deduce the optimization of the development mode of the existing information system of logistics enterprises and analyzed the development and operation mechanism of the information system of the logistics enterprises, as well as the expansion and reconstruction capability of their information system. In terms of game model, Zheng and Zhou [11] modeled the relationship between network slice tenants (NSTs) and users as a multimaster and multislave Stackelberg game, constructed the strategy space and profit function of both sides, and proved that there is a unique Nash equilibrium between users after NSTs decision-making. By analyzing the game model through backward induction, a distributed iterative algorithm was proposed to obtain the optimal throughput demand of users and the optimal slice pricing of NSTs. In the study of Zhou et al. [12], different game models were established to compare and analyze the optimal profit of the Stackelberg game of power suppliers in the traditional mode and cooperative game of power suppliers based on block chain, and finally, numerical simulation was conducted via MATLAB software. Xu et al. [13] established three pricing decision models based on game theory and gave corresponding analysis, in which the influences of three different green cost-sharing modes on product's retail price, greenness, and revenue of supply chain members were elaborated.

3. Informatization Development Model of Internal Control

It is mentioned in the "Guidelines for Internal Control" that "the development of information system for economic activities in colleges and universities can adopt such modes as self-development by departments, joint development by

multiple departments within the school, direct outsourcing of commercial software, and customized development by entrusting external units. Colleges and universities should fully assess the development and maintenance risks of the selected mode and make a plan to deal with the risks" The selection of software development mode in colleges and universities is constrained by various conditions such as cost, applicability, practicality, scalability, ease for maintenance, and security. In this paper, two modes of fully commissioned development and partial commissioned development are discussed.

Based on the game theory, the two parties involved in the game are the software development company A and the informatization management department B of internal control in colleges and universities. In the process of the game, it is assumed that both parties are fully rational economic persons, with the purpose of maximizing their respective interests.

3.1. Game of Software Development Model Selection. A's game strategy is (accept development, not accept development), and B's game strategy is (partially commissioned development, fully commissioned development). The probability of A accepting development is X, and that of not accepting development is 1-X. The relationship between A and B is based on benefit-sharing and risk-sharing. Let A bear the risks $Xf(\beta)$ $(X<1)$ arising from accepting development and B bear the corresponding losses $(1-X)f(\beta)$. So the payment matrix of both parties is: Table 1 shows the Single-game payment matrix based on risk-sharing for A and B.

The analysis is as follows.

When B chooses partially commissioned development, the revenue comparison that A chooses to accept and not to accept is

$$\begin{aligned}\left(E_A[1-Xf(\beta)]-C_A\right)-\left(E_A[1-f(\beta)]-C_A\right)\\ =(1-X)f(\beta)>0.\end{aligned} \tag{1}$$

At this time, A's choice to accept the strategy is more profitable than choosing not to accept the strategy.

When B chooses fully commissioned development, the revenue comparison that A chooses to accept and not to accept is

$$\left(E_A[1-f(\beta)]-C_A\right)-\left(E_A[1-f(\beta)]-C_A\right)=0. \tag{2}$$

At this time, A's choice to accept the strategy is equal to the benefits obtained when it does not accept the strategy.

It can be seen from the above two situations that no matter how B chooses, the revenue of A choosing not to accept the strategy is not higher than that of choosing to accept the strategy. Therefore, not accepting the strategy is the inferior strategy of A, and A chooses to accept the strategy according to the theory of eliminating inferior strategies.

When A chooses to accept, the revenue comparison of B's choice of partially commissioned development and fully commissioned development is

$$\begin{aligned}\left(E_B[1-(1-X)f(\beta)]-C_B\right)-\left(E_B-C_B\right)\\ =-(1-X)f(\beta)<0.\end{aligned} \tag{3}$$

At this time, B's choice of partially commissioned development strategy is less profitable than that of a fully commissioned development strategy.

When A chooses not to accept, the revenue comparison of B's choice of partially commissioned development and fully commissioned development is

$$\left(E_B-C_B\right)-\left(E_B-C_B\right)=0. \tag{4}$$

At this time, B gets the same revenue no matter choosing the fully commissioned development strategy or the partially commissioned development strategy.

It can be seen from the above two situations that no matter how A make the decision, the return of B choosing the partially commissioned development is not higher than that of choosing the fully commissioned development strategy. Therefore, the partially commissioned development strategy is the inferior strategy of B, and B chooses the fully commissioned development strategy according to the theory of eliminating inferior strategies.

In conclusion (accept, fully commissioned development) is the Nash equilibrium solution of the game problem.

3.2. Game of Software Maintenance Risk Management. In the event of an accident in system maintenance, first, A proposes a risk-sharing scheme S_1. If B approves it, the game ends; otherwise, B proposes a risk-sharing scheme S_2. If A approves it, the game ends; otherwise, A must accept the mandatory risk-sharing scheme S_3.

The content of the scheme S_1 is A bears the risk as X_1, B bears the risk as $f(\beta)-X_1$. If B agrees, then both parties bear the risk as $(X_1, f(\beta)-X_1)$.

The content of the scheme S_2 is A bears the risk as X_2, B bears the risk as $f(\beta)-X_2$. Due to the existence of opportunity cost, let the interest rate of opportunity cost remain unchanged as, if A accepts the scheme, the risk loss to be borne by both parties is $(\delta X_2, \delta[f(\beta)-X_2])$ (where δ is the risk negotiation loss coefficient, $\delta=1+r$).

The content of the scheme S_3 is: A bears the risk as X_3, B bears the risk as $f(\beta)-X_3$. The scheme S_3 is mandatory, and if the game round is missed, the total loss will keep rising. The longer the negotiation time, the more unfavorable it will be to both sides. If A and B fail to reach a consensus in multiple rounds of games and must accept the scheme S_3, then the risk loss to be borne by both parties is $\{\delta^2 X_3, \delta^2[f(\beta)-X_3]\}$.

If both sides of the game can reach an agreement as soon as possible, the game result will be more favorable to both sides. It is assumed that $X_2=\delta X_3$ and $X_1=\delta^2 X_3-\delta f(\beta)+f(\beta)$. Figure 1 shows the continuous dynamic game between A and B.

3.3. Marking the Dynamic Game Process Using Decision Trees. If both sides of the game can reach an agreement as soon as possible, the game result will be more favorable to both sides.

Table 1: Single-game payment matrix based on risk-sharing for A and B.

		The informatization management department of internal control in colleges and universities	
		Partially commissioned development	Fully commissioned development
Software development company	Accept (X)	$E_A[1 - Xf(\beta)] - C_A$, $E_B[1 - (1 - X)f(\beta)] - C_B$	$E_A[1 - f(\beta)] - C_A, E_B - C_B$
	Not accept ($1 - X$)	$E_A[1 - f(\beta)] - C_A, E_B - C_B$	$E_A[1 - f(\beta)] - C_A, E_B - C_B$

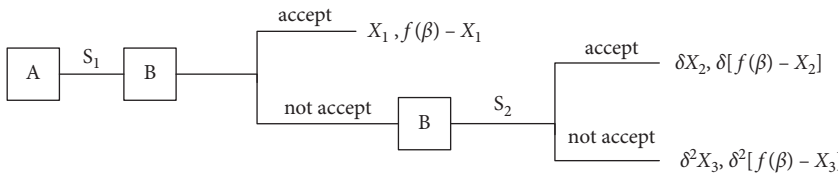

Figure 1: Continuous dynamic game between A and B.

The following is a recursive induction method to find the potential optimal solution:

If A does not approve the scheme S_2 but can only accept the scheme S_3, then A bears the risk as $\delta^2 X_3$, B bears the risk as $\delta^2[f(\beta) - X_3]$. If A approves the scheme S_2, then A bears the risk as δX_2, and B bears the risk as $\delta[f(\beta) - X_2]$. From $X_1 = \delta^2 X_3 - \delta f(\beta) + f(\beta)$, it can be concluded that $\delta X_2 = \delta^2 X_3$. It can be seen from that the risk of A approving the scheme S_2 is equal to that of accepting the scheme S_3, and then A may accept the scheme S_2 at this time.

Because $\delta^2[f(\beta) - X_3] - \delta[f(\beta) - X_2] = \delta f(\beta)\ (\delta - 1) = \delta f(\beta) r > 0$, B faces fewer risks in the second game than in the third game.

If B does not approve the scheme S_1 but A approves the scheme S_2, then A bears the risk as δX_2 and B bears the risk as $\delta[f(\beta) - X_2]$. If B approves the scheme S_1, then A bears the risk as X_1 and B bears the risk as $f(\beta) - X_1$. From $X_2 = \delta X_3$ and $X_1 = \delta^2 X_3 - \delta f(\beta) + f(\beta)$, it can be concluded that $(f(\beta) - X_1) - \delta[f(\beta) - X_2] = f(\beta) - \delta^2 X_3 - \delta f(\beta) + f(\beta) - \delta[f(\beta) - \delta X_3] = 0$. It indicates that B does not approve the scheme S_1, and the risks that A approves the scheme S_2 need to bear are equal to those that B approves the scheme S_1. In this case, B may accept the scheme S_1.

Because $\delta X_2 - X_1 = \delta\delta X_3 - (\delta^2 X_3 - \delta f(\beta) + f(\beta)) = \delta f(\beta)(\delta - 1) = \delta f(\beta) r > 0$, A is less risky in the first game than in the third game.

It can be seen from the above analysis that both A and B will gladly accept the scheme S_1 put forward by A in the first round, in which A bears the risk as $\delta^2 X_3 - \delta f(\beta) + f(\beta)$ and B bears the risk as $\delta f(\beta) - \delta^2 X_3$. So $(\delta^2 X_3 - \delta f(\beta) + f(\beta), \delta f(\beta) - \delta^2 X_3)$ is the subgame perfect Nash equilibrium solution of the game problem.

4. Case Study of Internal Control Information Construction in Colleges and Universities

Based on the above analysis, the complete delegation is a relatively optimal task allocation model, which has not only been tested theoretically but also corroborated by university cases.

For example, before the implementation of internal control information construction, the asset management system of University A was a system development task undertaken by the Information Office itself, and the financial platform was delegated to a system development company by the Finance Office. This development model uses a local delegation model. In actual use, it was found that there was a problem of information isolated island between the two systems, and data could not be interacted and shared due to the system compatibility problem between the systems. In the first phase of internal control information construction, the Internal Control Information Management Department of University A adopted a complete delegation model, that is, the contract management system and internal control data exchange platform were completely delegated to the system development company. After the two systems were put into operation, they solved the problems of development cycle and Scalability and were well received by all departments.

University A organized project review experts to evaluate the influence factors of the two different models, as shown in Table 2. In the complete delegation model, the system development cycle is fast, the system is more scalable and suitable, and the operation and maintenance risk is low, but the development cost is relatively high. But for universities, development cycle, system scalability, and suitability, operation and maintenance risks are more important than cost. In summary, the internal control information construction in University A has proved in practice that delegating the task to the system development company completely is a relatively optimal task allocation model.

5. Suggestions on the Informatization Construction of Internal Control in Colleges and Universities

With the informatization construction of internal control in colleges and universities, the management norms and processes of colleges and universities have been solidified and optimized, and changes have been made to the management model of various economic activities in colleges and

Table 2: Comparison table of influencing factors in the development model.

Delegation mode	Development cycle (10 points total)	Cost (10 points total)	System scalability (10 points total)	System suitability (10 points total)	Operation and maintenance risk (10 points total)	Total
Local delegation	5	7	4	5	5	26
Complete delegation	8	6	9	9	6	38

universities, which play a vital role in the implementation of the internal control system in colleges and universities. For this reason, how to implement internal control informatization is a major issue commonly faced by colleges and universities.

(5.1) When colleges and universities have a reserve of information technology talents, self-development and multidepartmental joint development modes on campus can save costs and facilitate the subsequent system maintenance; When colleges and universities do not have stringent requirements on the management and personnel of internal control, direct outsourcing of commercial software, and commissioning of external units to customize development modes can reduce maintenance risks. However, the disadvantage is that colleges and universities need to bear the commissioned development cost, and the technical personnel from the software company is required to participate in later maintenance. It is recommended that colleges and universities should make an assessment according to their own situations, rationally design the informatization construction plan of internal control, break down the information island or duplicate construction, and realize the effective connection between the existing information systems of various departments and the communication and sharing between existing information systems and new ones.

(5.2) With the acceleration of the informatization construction of internal control in colleges and universities, development and operation accidents frequently occur. Especially in the fully commissioned development mode, the stable operation of software and information security are particularly important. It is recommended that colleges and universities should be wary of any unexpected situations that may occur from the perspective of risk management, and timely formulate risk handling plans for the development and maintenance of internal control informatization construction to improve their ability to cope with emergencies and risks.

6. Conclusions

Based on the game theory, a game model of information development mode of internal control in colleges and universities and a game model of risk management of software maintenance are established in this paper. The two parties involved in the game are the software development company and the informatization management department of internal control in colleges and universities. It is verified by the model and case study that the fully commissioned development is an optimal development mode compared to the partially commissioned development mode. In future research, emphasis will be placed on exploring how colleges and universities can more effectively allocate the informatization construction tasks of internal control when facing more constraints in reality. What's more, from a practical perspective, future research will focus on exploring a systematic development mode that is suitable for the internal control informatization of administrative institutions. In this way, the research can provide theoretical support for the construction of internal control informatization of administrative institutions.

Data Availability

The data that support the findings of this study are available from the author upon reasonable request.

Conflicts of Interest

The author declares no conflicts of interest.

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