

Research Group Compliant Behaviour and Regulatory Choice under Incomplete Internal Control Supervision in Colleges and Universities

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Abstract: Subject to the realistic dilemma of insufficient supervision ability, the incomplete internal control supervision of scientific research projects will exist widely in colleges and universities in China for a long time and tend to be normal. Furthermore, exploring and designing effective internal control regulation strategies to deal with the violations of the research group have become an urgent practical problem to be solved in the internal control of colleges and universities. Based on the key supervision of the research group in Colleges and universities, this paper deeply discusses the dynamic choice of compliance behavior, the effectiveness of regulation strategy and its optimal design of the research group under the key supervision mechanism by using the method of game analysis. The research shows that under the condition of obvious constraints on the ability of school supervision, the carefully designed key supervision mechanism can become a powerful tool to guide and control the benign behavior of research groups in Colleges and universities.

Keywords: Internal control regulation, Game analysis, Key supervision, Compliant behavior of the research group.

1. Introduction

With the increasing promotion of the national innovation driven development strategy, the volume of scientific research funds in Colleges and universities has increased significantly year by year, becoming one of the important sources of funds for colleges and universities.

Although the large amount of funds from vertical and horizontal stimulate the research enthusiasm of innovation subjects, there is a problem of low efficiency in the use process: On the one hand, for researchers, the use of funds is cumbersome and laborious, a lot of time consumption and low financial level frustrate the enthusiasm of scientific research; On the other hand, in terms of the financial department, the management of scientific research funds is meticulous and large, and it is difficult to strictly control it. "Running, emitting, dripping and leaking" violations occur frequently in this regard, the State Council's "several opinions on further improving the fund management and other policies of central financial scientific research projects" proposed that the management of scientific research funds should adhere to the combination of "release, management and service", further streamline administration and delegate power, combine decentralization and management, and optimize services. However, while giving researchers greater autonomy, colleges and universities are also required to improve the internal management system, strengthen supervision during and after the event, and seriously investigate and deal with violations of law and discipline. In this context, how to combine rigid and flexible internal control has become a major test of the governance ability of colleges and universities.

In recent years, some researchers have embezzled funds and behaved badly, which has aroused widespread concern in the society. It also makes the scientific research funds and their internal control mechanism in Colleges and universities

become a research hotspot. For example, Fu ye and Sun Xiaoping analyzed the influencing factors of the illegal use of scientific research funds from the three dimensions of system, supervision and individual [1]. Xiao Fei and others discussed the problems existing in the current internal control and management of scientific research funds in Colleges and universities and put forward solutions [2]. Han Lei and Hu Bing tentatively put forward the implementation system of the reform of "release, management and service" of scientific research funds from four dimensions [3]. The reason is that the scientific research reputation of colleges and universities has the attribute of public goods. The research group in the university can share the convenience of project application brought by the reputation. For the reason of individual profit seeking, under the scenario of "reducing the burden and loosening the binding", individuals have the opportunity to take advantage, which will inevitably breed corruption. It can be seen that the internal control of scientific research funds is the result of the interaction of complex multiple interest conflicts, and the game method can better reveal the micro mechanism of the interests of multiple subjects. Therefore, some relevant scholars have applied the game idea to the research of internal control in Colleges and universities. For example, based on the perspective of game theory, Hu Li found the factors affecting the quality of financial information disclosure in Colleges and universities [4]. Zhao Naipu found measures to improve internal control and supervision through Game Modeling and equilibrium strategy analysis [5]. Zhao Hongman deeply analyzed the action mechanism of the behavior between users and managers of scientific research funds, so as to provide a theoretical basis for solving the problems in the financial reimbursement process of colleges and universities [6]. But generally speaking, such studies usually believe that individual behavior is completely rational, and it is difficult to explain the formation mechanism from individual to group behavior.

In reality, due to the long-term, incomplete information, rational differences of scientific research projects and so on, the behavior decisions of each game party show more limited rational characteristics, and it is usually difficult to judge the optimal strategy for complex games at one time, but seek the optimal strategy through dynamic processes such as imitation, learning and variation in multiple games.

Therefore, many scholars have used evolutionary game theory to better understand the emergence, transformation and stability of group behavior through the evolutionary analysis of strategic interaction. For example, after analysis, Jiang Xinran concluded that the internal control construction should balance the relationship between "retreat" and "pragmatism", and choose the corresponding strategies according to the different stages of internal control construction [7]. Through research, Xu Min and Pu Yuhui concluded that reasonable reward and punishment mechanism and efficient supervision system in Colleges and universities are important factors conducive to the evolution and stable formation [8].

However, the existing research rarely takes into account the increasingly prominent regulatory capacity constraints in the practice of scientific research fund management in Colleges and universities and their impact on internal control regulation strategies, and also lacks the investigation on the evolution and stability of internal control regulation strategies in Colleges and Universities under the constraints of capacity constraints.

To sum up, based on the existing research and from the perspective of incomplete research group supervision, this paper deeply discusses the evolution dynamics of research group research fund use behavior and the design of regulation strategy under the key supervision mechanism by constructing the game model of research group research fund use behavior selection under the key supervision mechanism and comprehensively using the analysis methods of classical game and evolutionary game, In order to provide an effective theoretical basis for relevant decision-making.

2. Problem Description and Model Assumptions

Considering that there are many research groups regulated by similar internal control in specific colleges and universities. Due to the limitation of supervision ability, it is difficult for colleges and universities to fully monitor the compliance status of all scientific research groups in Colleges and universities. Furthermore, in order to achieve the goal of internal control, under the existing internal control and supervision mechanism, colleges and universities plan to adopt specific principles to screen some scientific research groups, and focus on strengthening the supervision of such research groups by setting intensive monitoring frequency, strict punishment standards and other measures. In order to explain the model more clearly, the following assumptions are made in combination with the actual situation:

Hypothesis 1: the proportion of key supervision research groups in the research groups of colleges and universities is $R \in (0,1)$, and the strict supervision of colleges and universities can promote them to comply with the internal control regulation; Furthermore, the proportion of non key supervision research groups is $1-R$. Use $\gamma_i \in \{0,1\}$ to refer to the internal control compliance of non key supervision research groups, in which, $\gamma_i = 0$ indicates that the research

group chooses to use scientific research funds in violation of regulations, and $\gamma_i = 1$ indicates that the research group complies with internal control regulations.

Hypothesis 2: The compliance decision of non key supervision research groups is based on the trade-off between compliance cost and violation cost: If they want to comply with internal control regulations, they will lose additional benefits $c > 0$; If they do not comply, they will face "punishment" from the competent scientific research departments, the public, schools and other aspects. Due to the limitation of supervision ability, the expectation value v of punishment for violations of non key supervision research group is positively correlated with the overall compliance degree h of research group in Colleges and universities; In other words, the more research groups that comply with internal control in Colleges and universities, the more likely the research group will be monitored for violations and the social punishment will also increase. In short, suppose $v = \theta h$, where $\theta \geq 0$ can be understood as the maximum punishment received by the research group for violation.

Hypothesis 3: the internal control compliance degree h of the research group in Colleges and universities can be reflected by the proportion of the internal control compliance group in the research group in Colleges and universities, that is $h = R + (1-R)\bar{\gamma}$, Among them, $\bar{\gamma}$ is the internal control compliance of non key supervision research group (i.e. compliance proportion), $\bar{\gamma} \in [0,1]$.

Based on the above assumptions, if the utility of selecting violation strategy is regarded as 0, the expected utility of the research group's compliance with internal control is $\theta h - c$; Furthermore, for any research group i not included in the scope of key supervision, its expected utility can be uniformly modeled as:

$$U_i = U(\gamma_i, \bar{\gamma}) = (\theta h - c)\gamma_i = \{\theta[R + (1-R)\bar{\gamma}] - c\}\gamma_i \quad (1)$$

It is not difficult to see that, under the key supervision mechanism, the optimal strategy choice of non key supervision research groups depends on the internal control strategy R of colleges and universities and the strategy choice of other research groups in the universities. Then, using the analysis method of complete information static game, proposition 1 can be obtained.

Proposition 1 When $\theta < c$, the game has a unique Nash equilibrium state; When $\theta > c > R\theta$, the game has three Nash equilibrium states, namely $\bar{\gamma} = 0$, $\bar{\gamma} = 1$ and $\bar{\gamma} = (c/\theta - R)/(1-R)$; When $\theta R > c$, the game has a unique Nash equilibrium state: $\bar{\gamma} = 1$.

Prove: As previously known, for any non key regulatory research group, the expected utilities of compliance and non-compliance are $U(0, \bar{\gamma}) = 0$ and $U(1, \bar{\gamma}) = \theta[R + (1-R)\bar{\gamma}] - c$ respectively. Furthermore, if $\bar{\gamma} = 1$ is a Nash equilibrium state, condition $U(1,1) = \theta - c > 0$ must be satisfied; if $\bar{\gamma} = 0$ is a Nash equilibrium state, condition $U(1,0) = \theta R - c < 0$ must be satisfied.

At the same time, if $\theta[R + (1-R)\bar{\gamma}] - c = 0$, the non key regulatory research group has the same utility whether it complies with internal control or not, so

$\bar{y} = (c/\theta - R)/(1 - R)$ is also a possible equilibrium state. It can be seen from $0 < \bar{y} < 1$ that $R\theta < c < \theta$ is the condition that needs to be met in this equilibrium state. Based on the above analysis, the proposition can be obtained. End of proof.

3. Three Dynamic Analysis on The Behavior Evolution of The Research Group Under Key Supervision Mechanism

Evolutionary game theory is a theory that combines game theory with biological dynamic evolution process to study economic system. This method mainly analyzes the equilibrium point and stability of strategic communication of game players [12].

Assuming that among the non key regulatory research groups, the proportion of choosing to comply with the internal control strategy is x ($0 \leq x \leq 1$), i.e. $\bar{y} = x$, the proportion of choosing the violation strategy is $1 - x$; The fitness of different strategies is expressed by expected utility. Furthermore, the fitness of non key regulatory research group to select compliance strategy and violation strategy is $U(1, x)$ and $U(0, x)$ respectively; Average fitness is $\bar{U}(x) = xU(1, x) + (1 - x)U(0, x)$.

According to the Malthusian dynamic equation, the growth rate \dot{x}/x of the proportion of non key regulatory research groups that comply with internal control is equal to their fitness $U(1, x)$ minus the average fitness $\bar{U}(x)$. After sorting, the differential equation of the replication dynamic process can be obtained as follows:

$$\dot{x} = x[U(1, x) - \bar{U}(x)]$$

Table 1. Stability analysis of each equilibrium point

Stability discriminant of each equilibrium point	Symbols of stability discriminant under different conditions		
	$c > \theta$	$R\theta < c < \theta$	$c < R\theta$
$f'(x) _{x=0} = \theta R - c$	< 0	< 0	> 0
$f'(x) _{x=1} = -(\theta - c)$	> 0	< 0	< 0
$f'(x) _{x=x'} = \frac{(c - R\theta)(\theta - c)}{\theta(1 - R)}$	non-existent	> 0	non-existent

The dynamic trend and stability of system evolution under different conditions are shown in Figure 1.

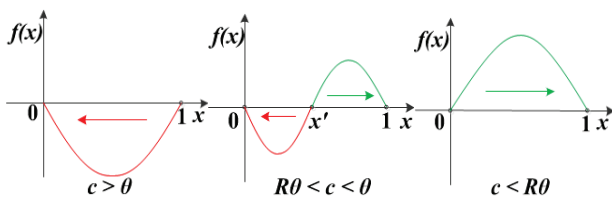


Figure 1. Dynamic phase diagram of group replication of research group under different conditions

Based on the above propositions, under the key supervision mechanism, the compliance behavior choice of the research group is closely related to its compliance cost C , violation cost θ and school internal control strategy R .

If the compliance cost of the research group is too high, i.e.

$$= x(1 - x)\{\theta[R + (1 - R)x] - c\} \triangleq f(x) \quad (2)$$

The following conclusion can be drawn from $f(x) = 0$.

Proposition 2 Dynamic system (2) must have two equilibrium points: $x = 0$ and $x = 1$; When $R\theta < c < \theta$, there is another equilibrium point: $x = (c/\theta - R)/(1 - R) \triangleq x'$.

Prove: When $x = 0$ or $x = 1$, there is always $f(x) = 0$, so $x = 0$ and $x = 1$ are the equilibrium points of the dynamic system. When $0 < x < 1$, if $\theta[R + (1 - R)x] - c = 0$ is satisfied, there is also $f(x) = 0$;

The solution shows that $x = (c/\theta - R)/(1 - R)$ is the possible equilibrium point of the system, it is easy to get from $0 < x < 1$, the existence condition of this point is $R\theta < c < \theta$. End of proof.

The equilibrium point obtained by copying the dynamic equation is not necessarily the evolutionary stable strategy (ESS) of the system. Due to the requirements of evolutionary stability strategy $f'(x) < 0$ [10], the stability of equilibrium points in different cases can be obtained by analysis, as described in proposition 3.

Proposition 3 when $c > \theta$, the dynamic system (2) has a unique ESS: $x = 0$; When $R\theta < c < \theta$, there are two ESS in the system: $x = 0$ and $x = 1$; When $c < R\theta$, the system has a unique ESS: $x = 1$.

Prove: Derivative equation 2 to x , calculate the stability judgment expression of each equilibrium point in Proposition 2; Then the local stability of each equilibrium point is analyzed in three cases. The results are shown in Table 1. According to the requirements of evolutionary stability strategy, it is easy to get this proposition. End of proof.

$c > \theta$, the non key regulatory research groups choose violation is the final evolutionary stable state.

If the compliance cost of the research group meets $R\theta < c < \theta$, the final result of the behavior choice of the research group also depends on the proportion of the compliance research group in the non key control research group, that is, only when the proportion of research groups complying with the regulation meets $x > x'$, the research groups in the university only can evolve towards full compliance with the regulation; Due to

$$\frac{dx'}{dR} = \frac{c - \theta}{\theta(1 - R)^2} < 0 \quad (3)$$

That is, x' is negatively correlated with R , so the university can indirectly guide the benign behavior of non key regulatory research groups by improving R . Until $c < R\theta$,

the research group in Colleges and universities will eventually choose to follow the internal control strategy.

4. Analysis on the Internal Control Strategy of Colleges and Universities Under the Key Supervision Mechanism

There is no doubt that the key supervision mechanism is actually the optimization strategy choice of the University for the supervision of the existing scientific research group under the realistic constraints of the supervision ability. Furthermore, the analysis of the effectiveness and efficiency of it still needs to be rooted in the behavior choice of the research group under the existing internal control and supervision mechanism ($R = 0$).

According to proposition 3, when the key supervision mechanism is not introduced ($R = 0$), there are two main situations of system evolution phase (as shown in Figure 2):

- ① When $c > \theta$, all research groups will tend to fail to comply;
- ② When $c < \theta$, the behavior choice of the research group depends on the proportion x_0 of the research group that initially chooses to comply with the regulation in the University, That is, when $x_0 < c/\theta$, all research groups will still tend to fail to comply; When $x_0 > c/\theta$, the compliance policy will be adaptive. The existence of this situation undoubtedly provides a theoretical basis for colleges and universities with limited supervision ability to focus on the supervision of scientific research funds on the basis of existing supervision. However, it should be noted that the regulatory variable of Universities under the key regulatory mechanism is R , and it will not directly change the penalty structure faced by the non key regulatory research group. Therefore, when $c > \theta$, as long as $R \neq 1$, the evolutionary equilibrium state must be $x = 0$, which is independent of the internal control strategy R . Its practical meaning is: when the compliance cost of the scientific research group is higher than the violation cost, the key supervision mechanism cannot promote the evolution of the benign environmental behavior of the scientific research group; At the same time, even if the key supervision can achieve good results temporarily, once the mechanism is abolished, the research group will still return to the situation of illegal use of scientific research funds.

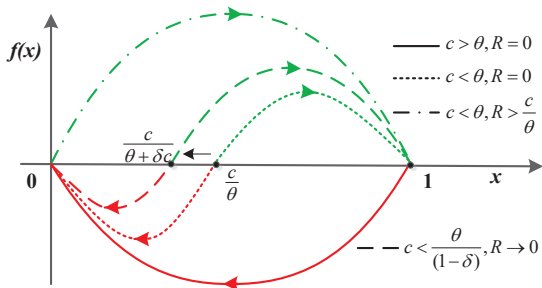


Figure 2. Dynamic diagram of system evolution under different internal control strategies

The above analysis also shows the applicable boundary of the key supervision mechanism of the scientific research group, that is, colleges and universities need to improve the existing supervision mechanism through a series of measures to reduce the compliance cost of the research group and

increase the cost of violations, which should at least meet: $c < \theta$. From the previous analysis, it can also be found that when $c < \theta$, although the behavior choice of the research group that is not included in the key supervision scope also depends on the proportion of the research group that chooses to comply with the internal control regulation, however, by reasonably designing the internal control regulation strategy, colleges and universities can achieve a good guidance for the transformation of non key supervision research groups to comply with the internal control strategy.

Proposition 3 also shows that when the regulation strategy $R > c/\theta$ is satisfied, $f(x) > 0$ excites for any x , $x = 1$ becomes the only ESS for any. In other words, under this strategy, the non key supervision research group will find that the compliance strategy is relatively favorable and will tend to comply through continuous attempt, learning and adaptive adjustment of the existing strategy. Therefore, when a, the key supervision mechanism can fundamentally solve the violation situation of the research group. Therefore, when $c < \theta$, the key supervision mechanism can fundamentally solve the violation situation of the research group. More importantly, in theory, once the proportion of compliance research group in Colleges and universities exceeds c/θ through key supervision, the compliance behavior of the research group will continue even if the mechanism is revoked. The specific description is described in inference 1.

Inference 1 Under the existing internal control and supervision, if a, the introduction of key supervision mechanism cannot completely improve the violation situation of the research group; However, through the regulation adjustment of internal control strategy, as long as B meets C, the research group will eventually tend to comply with the regulation; At the same time, when the proportion of subject groups in Colleges and universities exceeds D, even if the key supervision mechanism is revoked, the system will still evolve into an ideal pattern that all subject groups comply with.

The connotation of inference 1 is worth pondering. It essentially reflects the optimal design of internal control regulation in Colleges and universities, which should promote the emergence of norms through evolution [8]. Under the existing internal control and supervision mechanism, the research group does not have an obvious restraint mechanism in the recognition of scientific research funds.

However, once some research groups are included in the key supervision, they will be dissatisfied with the violate regulations research group due to the loss of their own additional income, and then have a strong motivation to exert pressure on the illegal research group through a series of means such as illegal behavior reporting and inter research group reputation mechanism to force it to comply with the regulation of internal control strategy.

In addition, the practice of key supervision in China also pays relative attention to the dynamic management of key supervision research groups, that is, the list of key supervision is dynamically adjusted regularly according to the statistics of scientific research projects and supervision data, in order to strengthen the direct deterrence to non key supervision research groups. Under this strategy, the punishment faced by the non key supervision research group for violations needs to take into account the expected cost of being included in the key supervision in the next period. It may be assumed that the discount coefficient of the research group is $\delta \in (0,1)$; The

probability that the non key supervision research group that chooses the violation strategy in the current period will be included in the key supervision in the next period depends on the overall internal control strategy compliance h of the research group in the University, that is, the more the compliance research group, the greater the probability that the violation research group will be included in the key supervision. At this time, the expected social punishment faced by the non key supervision research group for violation is $v = \theta h + \delta hc$; Furthermore, the replication dynamic equation of system evolution under the dynamic management strategy of key supervision list is transformed into:

$$\dot{x} = x(1-x)\{(\theta + \delta c)[R + (1-R)x] - c\} \quad (4)$$

Similarly, proposition 4, proposition 5 and inference 2 can be obtained:

Proposition 4 dynamic system (4) must have two equilibrium points: $x=0$ and $x=1$; When $1 - \delta > c/\theta > R/(1 - \delta R)$, there is another equilibrium point:

$$x = (c - \theta R - \delta cR)/[(1-R)(\theta + \delta c)] \triangleq x''.$$

Proposition 5 when $c > \theta/(1 - \delta)$, the dynamic system (4) has a unique ESS: $x=0$; When $c < R\theta/(1 - \delta R)$, the system has a unique ESS: $x=1$; When $R\theta/(1 - \delta R) < c < \theta/(1 - \delta)$, there are two ESS in the system: $x=0$ and $x=0$.

Inference 2 under the supervision of the existing internal control strategy, if $c > \theta/(1 - \delta)$, the introduction of key supervision cannot completely improve the violation situation of the research group; Through the regulation adjustment of internal control strategy, when $c < \theta/(1 - \delta)$ meets $R > c/(\theta + \delta c)$, the research group will tend to comply; However, only when the proportion of compliance research groups in Colleges and universities exceeds c/θ , the revocation of key supervision mechanism will not affect the ideal pattern of full compliance of system evolution.

It can be seen from the above conclusions that integrating the dynamic management strategy of key supervision list can more effectively realize the guidance and control of the compliance behavior of the use of scientific research funds of the research group: Because of $\theta < \theta/(1 - \delta)$, the boundary condition of "key supervision can promote all research groups to fully comply with" is easier to meet; Moreover, under this strategy, even if the key supervision is extremely weak ($R \rightarrow 0$), as long as the proportion of research groups initially selected to comply in Colleges and universities exceeds $c/(\theta + \delta c)$, all research groups can tend to comply by relying solely on the existing incentive mechanism, as shown in Figure 2. However, it is worth noting that ① the strategy cannot guarantee the establishment of key regulatory mechanisms once and for all:

In case of $c > \theta/(1 - \delta)$, the existing regulatory mechanism still needs to be adjusted, otherwise the system still has the possibility of "converging to all non key regulatory research groups breaking the rules"; ② The effectiveness of this strategy will decline with the reduction of the discount coefficient of the research group; When $\delta \rightarrow 0$, the strategy will not play any role; ③ This strategy

is an important supplement to the key supervision mechanism. Therefore, before canceling the key supervision, it is still necessary to ensure that the proportion of the research group that obeys rules in Colleges and universities exceed c/θ . Otherwise, the system will evolve to a bad pattern again.

5. Conclusions and Suggestions

Subject to the practical dilemma of the limitation of supervision ability, incomplete internal control supervision will exist widely in Colleges and universities in China for a long time and tend to be normal. Furthermore, exploring and designing effective regulation strategies to deal with the fraud of research funds have become an urgent practical problem in internal control. Based on the key supervision of research groups in Colleges and universities, this paper deeply discusses the behavior selection and regulation strategy design of research groups under the key supervision mechanism by using the method of game analysis. Specifically speaking: Firstly, combined with the analysis of the actual situation, this paper constructs a game model of the compliant behavior choice of the research group under the key supervision mechanism; Then, the dynamic evolution process and equilibrium stability of the behavior decision-making of the research group are investigated by using the evolutionary game method, and the effectiveness and optimization of the internal control regulation strategy under this mechanism are demonstrated in detail; At the same time, integrating the dynamic management strategy of the supervision list can make the key supervision mechanism play an effective role in a wider scope of application. To sum up, the behavior choice of the research group is closely related to its compliant cost, violation cost and regulation intensity. Under the inherent constraints of supervision ability, the well-designed key supervision mechanism can become a powerful tool to induce and control the compliant behavior of research groups in Colleges and universities.

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