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# Optimization of the internal control quality of companies listed on the Iranian stock exchange using the imperialist competitive algorithm

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**Abstract**

Internal controls and their improvement are essential issues in organizations and companies. Therefore, this mixed research was conducted to optimize the quality of internal controls of companies listed on the Iranian Stock Exchange using the imperialist competitive algorithm. This mixed study was conducted on 29 variables in the qualitative section by interviewing 18 experts to optimize the quality of internal controls of companies listed on the Iranian Stock Exchange. Qualitative and quantitative data analysis reached five stages of implementation. In the implementation of the fifth stage, 1550 repetitions were obtained, and the quality level of internal controls was reduced by 1.3473, which is the best possible value for the objective function. Paying severe attention to the systemic approach in the internal control system of companies can lead to a significant improvement in the internal controls of listed companies and enhance their performance. In addition, the effect of the systemic approach affects the level of shareholder satisfaction and the quality of risk detection and evaluation.

Keywords: Internal controls, Quality, Improvement
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## 1 Introduction

According to recent beliefs, weak internal control has reduced the quality of financial information, thereby providing opportunistic conditions for managers. Therefore, companies with weak internal controls increase investment inefficiency [19]. High-quality internal control systems in economic units are essential in achieving the effectiveness and efficiency of operations, improving accountability, financial transparency, compliance with laws, and helping to prevent fraud and financial abuse [7]. As a financial market grows, different problems and opportunities require different solutions. Therefore, more problems occur in performing supervisory tasks, which can create risks and prevent companies from achieving their goals. Every organization should improve the quality of control aspects [1]. Therefore, a high-quality internal control system is a basic control tool in companies as modern economic conditions to achieve a competitive advantage over other companies. Currently, internal control has become a tool for risk control that helps

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companies achieve their goals and tasks [12]. According to the instructions of internal controls of issuers listed on the Tehran Stock Exchange, the board of directors of companies is obliged to establish effective internal controls [13]. Therefore, this study aimed to find a method to optimize the quality of internal controls of companies listed on the Iranian Stock Exchange using the imperialist competitive algorithm.

## 2 Theoretical foundations and research literature

Studies on determinants and economic implications of internal control (IC) quality have risen in recent years. According to these studies, the improvement of internal control quality, even in financial decisions in the United States, has shifted from general aspects of internal control to more features, including inventory, information technology (IT), and tax-related internal control aspects [8]. The long-term process of transforming companies into large organizations, including companies with technical and specialized activities and the number of personnel, has prevented the managers of such companies from directly monitor over the operations. Under these conditions, managers can no longer rely on personal observations to evaluate the results of operations and the financial condition of the company. Therefore, establishing a high-quality control and monitoring system is critical to advancing the goals of companies [10]. Internal control is a process designed and implemented by management and other staff to make a rational assurance of achieving the goals in terms of the reliability of financial reporting, the effectiveness and efficiency of operations, and compliance with relevant laws and regulations. Therefore, internal controls are designed and implemented to identify business risks threatening the achievement of each goal. Internal controls are an element and an integral part of any economic unit. Most decisions of managers and economic decision-makers are made based on financial information provided by the accounting system, and a high-quality control system improves the reliability of this information. The stronger and better the quality of internal controls, the risk of distortion is significantly reduced and, consequently, the risk of auditing is reduced [14]. Accountability, respect for stakeholder rights and financial transparency, and increasing the quality of internal control are considered regarding the role of corporate leadership in the optimal use of resources. Indirect control of organizational operations and the distance of senior managers from the activities of the business unit has led management to establish an effective internal control system as an integral part of the efficient management system and prevent any abuse by adopting intelligent measures [11]. A high-quality control can help the organization achieve its goals and prevent the wastage of resources. Therefore, creating a set of internal controls should be seriously considered by the professional community [6]. Accordingly, [4] found that company size, using four auditors, the ratio of non-audit to total costs, the need for other types of accounting, number of audit committee meetings positively affect the amendment of the internal control report. [2] stated that most of the internal control weaknesses at the company level are severely limited by the incentives provided by shareholders. However, these weaknesses are more related to the motivations of managers. [20] evaluated the factors affecting the important weaknesses in internal controls and showed that companies with weaknesses are smaller, more complex, financially weaker, have a growth slowdown with no effect on stock prices, and are disabled to identify major weaknesses. [11] investigated the effect of internal control and managerial performance on local government accountability in Indonesia and concluded that both affect financial accountability in the local government of Indonesia. [5] examined the effect of internal audit features on the effectiveness of internal control on the performance verification of Taiwanese companies and revealed that a larger internal audit team could increase internal audit performance for both functions. [1] studied the effect of internal control on employee performance in small and medium-sized enterprises in Jordan by miniaturizing the role of the accounting information system. The results showed that accounting information systems mediate the relationship between internal control and employee performance. [9] assessed the factors affecting the internal control weaknesses and found a positive and significant relationship between stock price logarithm in the number of shares, the ratio of inventory to total assets, and losses with the weaknesses of the internal control. [3] evaluated the effectiveness of internal controls on the financial violations of the executive bodies of West Azerbaijan province and stated a significant effect of the establishment cost and all components of internal control except information and communication on financial violations. [13] investigated the relationship between managers' overconfidence and the prevailing internal controls of financial management and indicated that managers' overconfidence has a positive and significant relationship with weaknesses and the importance of internal controls. [7] studied d the effect of agency costs on the relationship between the quality of internal controls and earnings management and showed that agency costs moderate the relationship between the quality of internal controls and corporate profit management. [18] developed an optimal internal control model by emphasizing the role of management system criteria with an artificial intelligence approach. The forecast results indicated that CHAID's[1] [6] legal-oriented artificial intelligence algorithm (with a power of more than 58%) could predict the desirability of internal control of companies listed on the Tehran Stock Exchange.

[1] Chi-square automatic interaction detection

## 3 Research methodology

This applied study aimed to optimize the quality of internal controls of companies listed on the Iranian Stock Exchange using the imperialist competitive algorithm, as well as a mixed research method (qualitative-quantitative). The imperialist competitive algorithm (ICA) was used to extract the variables from the semi-structured interviews and open coding to reach the variable and optimize the quality variables of internal controls. The imperialist competitive algorithm (ICA) is based on the growth and development of empires and initially starts from several countries in the initial state. Countries are divided into two categories: colonial countries and colonized countries. The algorithm slowly improves the countries (problem solutions) with certain processes, and finally, the appropriate solution (optimal country) of the optimization problem is obtained. This solutions algorithm puts the problem, which is the same countries, in a repetitive loop, gradually improves them, and finally reaching the optimal solution. The stages of the imperialist competitive algorithm (ICA) are as follows:

$$Country = [p_1, p_2, \ldots, p_{Nvar}] \tag{1}$$

A number of these countries should be created to start the algorithm. Therefore, the matrix of all countries is formed randomly:

$$Country = \begin{bmatrix} Country1 \\ \ldots \\ Countryn \end{bmatrix} = \begin{bmatrix} R1, R2, R3, \ldots, R29 \\ \ldots \\ R_{n-9}, R_{n-8}, \ldots, R_n \end{bmatrix} \tag{2}$$

$$Cost_i = f(Country_i) = f(p_1, p_2, \ldots, p_{Nvar}) \tag{3}$$

This function will be in the form of the following equation for optimizing the quality of internal controls to minimize errors:

$$F = \sum_{i=1}^{12} (D_i - R_i)^2 \tag{4}$$

$$C_n = \max\{C_i\} - C_n \tag{5}$$

In which, $C_n$ presents the error cost of nth imperialist, $C_n$ represents the normalization cost of nth imperialism, and $maxC_i$ donates the highest cost among the imperialists. The higher the error costs of imperialism, the weaker the normalization costs. Therefore, the power of imperialism to allocate colonial countries is derived from the following equation:

$$P_n = [\frac{C_n}{\sum_{i=1}^{Nvar} C_i}] \tag{6}$$

In other words, the normalized power of an imperialist is the ratio of the colonies ruled by that imperialist. Thus, the initial number of colonies of an imperialist would be equal to:

$$N.C_n = round\{P_n - (Ncol\} \tag{7}$$

**Acquisition policy:** Colonial countries used various methods to gain more influence in the colonized countries, such as establishing universities and applying their official language in educational environments, changes in traditions and culture, the development (construction of railways and hospitals, etc.). In line with this policy, the colony country moved X units toward the colony's line to the colonizer and pulled out to the position. X is a random number with a uniform distribution (or any other appropriate number), shown in Figure 1.

If the distance between the colonizer and the colony is denoted by d, then:

$$X \sim U(0, \beta \times d) \tag{8}$$

In which, $\beta$ is greater than 1 and close to 2, but the proper option can be $\beta = 2$. The coefficient of $\beta \geq 1$ causes the colonial country to approach the colonizing country from different directions. Therefore, the angle of deviation is also considered. According to Figure 2

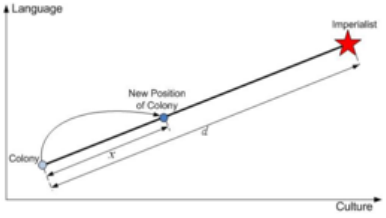


Figure 1: Linear movement of the colony in the direction of the colonizer

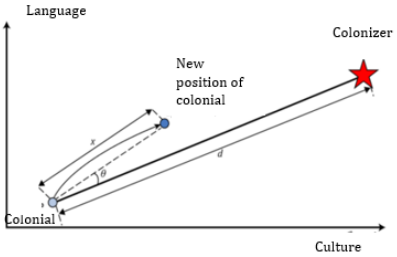


Figure 2: The acquisition policy in the imperialist competitive algorithm

**Transfer of power between the colonizer and the colony:** As a result of implementing some policies by the colonial countries, the colonial countries gained self-confidence.

**Total power of an empire:** The power of an empire is equal to the power of the colonial country, plus a percentage of the total power of its colonies. Thus, the total cost of an empire is obtained from the following equation:

In which, $T.C_n$ indicates the total cost of the nth empire and $\xi$ is a positive number usually considered between zero and one and close to zero. Small $\xi$ equals the total cost of an empire approximately to the cost of its central government (imperialist country), and increasing $\xi$ raises the effect of the cost of an empire's colonies in determining its total cost. In the typical case,$\xi = 0.05$ in most implementations has led to an optimal solution.

**Revolution:** The emergence of a revolution causes sudden changes in the socio-political characteristics of a country.

**Colonial Competition:** Colonial competition is the competition that imperialist countries wage to gain more influence and power to maintain their monarchy. First, the probability of each empire, which is proportional to the power of that empire, is calculated in the following order considering the total cost of the empire to model the rivalry between empires for possession of these colonies. Initially, the normalized total cost is determined from the total cost of the empire:

$$N.T.C_n = \max\{T.C.i\} - T.C.n \tag{10}$$

$$P_{pn} = |\frac{N.T.C.n}{\sum_{i=1}^{Nimp} N.T.C.n}| \tag{11}$$

A mechanism such as the roulette wheel in a genetic algorithm is required, given the probability of taking over any empire, to provide one of the competing colonies with a probability commensurate with the power of the empires. The vector P is formed from the above probability values given the probability of conquering each empire to divide the said colonies randomly, but with the probability of possessing each empire between other empires.

$$P = [P_1, P_2, \ldots, P_{Nimp}] \tag{12}$$

$$R = [r_1, r_2, \ldots, r_{Nimp}] \tag{13}$$

$$r_1, r_2, \ldots, r_{Nimp} \sim U(0,1) \tag{14}$$

Then, the vector D is formed as follows:

$$D = P - R = [D_1, D_2, \ldots, D_{Nimp}] = [P_1 - r_1, P_2 - r_2, \ldots, P_{Nimp} - r_{Nimp}] \tag{15}$$

These colonies are given to an empire with a vector D whose corresponding index in vector D is greater than the others. The empire, which is most likely to take over will most likely get the highest index in the D vector. The lack of need for calculating CDF makes this mechanism work faster than the roulette cycle.

**The Fall of Weak Empires:** As stated, weak empires gradually fall during imperialist rivalries, and their colonies fall into the hands of stronger empires.

**Convergence in the imperialist competitive algorithm:** The algorithm will run until providing a convergence condition, or all iterations are complete. The objective function of maximizing the quality of internal controls to optimize the quality of internal controls of companies listed on the Iranian Stock Exchange is:

$$Function = \max \lambda_t \tag{16}$$

In which, $\lambda$ is the value of the quality of internal controls, which should be maximized, and $t$ is the period considered.

**System constraints:** The current quality level of internal controls is determined by the continuity relation, which is defined as the following equation, which is used in the algorithm process to obtain the quality level of internal controls at each time step:

$$S_{t+1} = S_t + I_t - R_t - E_t - S_{pt} \tag{17}$$

$S_{t+1}$: Quality level of internal controls at the end of the course

$S_t$: Quality level of internal controls at the beginning of the course

$I_{t+1}$: Improvement level of the quality of internal controls during the period

$R_t$: The level of quality reduction of internal controls during the period

$E_t$: Quality level of internal controls at the end of the course $S_{pt}$: Improvement level of the quality of internal controls exceeded expectations at the end of the course

$$R_{min} \leq R_t \leq R_{max} \tag{18}$$

$$S_{min} \leq S_t \leq S_{max} \tag{19}$$

The quality level of internal controls depends on the inputs and outputs and the quality level at the beginning of the previous period because the amount of input and output variables affects the quality level of internal controls. Therefore, this constraint, a kind of continuity, continues as a chain and should be applied in the body of the algorithm. The statistical population in the qualitative section included a set of academic and organizational experts familiar with internal controls. The sample size is based on theoretical adequacy so that no new index or variable is identified in interviewing the statistical population of elites. Therefore, the criterion of sample adequacy is theoretical saturation. In the beginning, 12 people were identified as the sample of primary experts using the purposive sampling method, and then the necessary data were collected. New people were identified during the interview, which interviewed 18 individuals and resulted in theoretical saturation. Theoretical saturation was achieved when the additional data did not help to complete and specify the dimensions of the research, and the data collected after the fourteenth interview seemed similar. According to the study, 57% of the sample of research experts had a scientific and research background in universities, and 21% of them had a history of auditing in various Iranian organizations in the studied subject. Furthermore, 22% of the experts had a long history of stock exchange auditing and higher university education. The average work experience of academic experts and auditors of organizations was between 14 and 17 years old, and the work experience of expert auditors of the stock exchange was 13 years, indicating proper experience and full familiarity with the required variables.

## 4 Findings

This study aimed to describe the phenomenon of internal controls in the most detailed way possible in the form of optimization. Therefore, out of more than 217 passages after coding the data from the interview, 105 were coded, and then the variables were extracted (Table 1).

Table 1: Coding and extracting internal control optimizer concepts

| No | Open coding | Extracted variable |
|---|---|---|
| 1 | Systems thinking to internal controls | Systematic approach to internal controls |
| 2 | Using structural analysis in designing and performing internal controls | |
| 3 | Pay attention to the functional composition of internal controls | |
| 4 | Pay attention to information asymmetry | Financial reporting quality |
| 5 | Competitiveness level of reporting quality between shareholders | |
| 6 | Quality of capital market pressure analysis in financial statements | |
| 7 | Expandable financial reporting | |
| 8 | Intermediate financial reporting | |
| 9 | Providers of financial statements | Financial reporting chain |
| 10 | Internal control system | |
| 11 | General competence of approvers of financial statements | |
| 12 | Accounting for financial statements | |

As shown, the obtained propositions are coded, and 29 research variables are extracted in the same procedure (Table 2).

Table 2: Extracted variables improving internal controls

| Code | Variable title | Code | Variable title |
|---|---|---|---|
| 1 | The competence level of the participants in the control measures | 15 | Comprehensive control |
| 2 | Quality of diagnosis and risk assessment | 16 | Improving the level of security of assets and equipment |
| 3 | Financial reporting quality | 17 | Documentation of cost justification |
| 4 | Index of errors and shortcomings | 18 | Developing appropriate policies and procedures for internal controls |
| 5 | Promoting ethical standards | 19 | Creating operation records of internal controls |
| 6 | Analysis of organizational goals | 20 | Reliable information system |
| 7 | Financial reporting chain | 21 | Balanced information distribution |
| 8 | Proper leadership and governance of internal controls | 22 | Establishing communication lines for confidential information |
| 9 | Ensuring the clarity of organization | 23 | Quality control of internal control process |
| 10 | Making people accountable for their responsibilities | 24 | Matching actual performance with goals and budget |
| 11 | Systematic approach to internal controls | 25 | External audits |
| 12 | Customer and employee surveys | 26 | Improved control environment |
| 13 | Development of corrective measures | 27 | Satisfaction level of shareholders |
| 14 | Restrictions on access to financial information | 28 | Dependence on internal audit performance management system |
| | | 29 | Adequacy of reports |

The variables identified in Table 2 were provided to the experts using the Likert spectrum. Then, the collected data from the questionnaire were imported into the imperialist competitive algorithm. The appropriate parameters of the imperialist competitive algorithm are calculated by trial and error in Table 3.

Table 3: The appropriate value of each of the parameters of the imperialist competitive algorithm (ICA)

| NC | NI | RC | AC | [6] | $\alpha$ |
|---|---|---|---|---|---|
| 750 | 130 | 0.03 | 1.5 | 0.03 | 1 |

According to Table 3, the most appropriate value of each of the parameters of the imperialist competitive algorithm (ICA) was the number of countries (750), number of colonizers (130), revolution rate (0.03), acquisition coefficient (1.5), zeta coefficient (1.5), and alpha (1). The results of 5 times the implementation of the colonial competition algorithm concerning the optimal values of the parameters of this algorithm are shown in Table 4. According to the stop conditions of this algorithm, the program will stop running if the value of the target function does not change more than 0.1 during 50 consecutive repetitions.

Table 4: Results of five times implementations of the imperialist competitive algorithm (ICA)

| Implementation No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Number of iteration | 1340 | 1356 | 1371 | 1400 | 1550 |
| Value of objective function | 2.7235 | 2.5957 | 1.9271 | 1.404 | 1.3473 |

Table 4 present the number of iterations (1340), the value of the objective function (2.7352), and the level of

reduction of the quality of internal controls until the fifth execution with iteration number (1550). As shown, a lower and better value is obtained for the objective function in the fifth implementation compared to other performances.

Table 5: Statistical characteristics of the performance of the imperialist competitive algorithm implemented five times

| Average values of the objective function | The best value of the objective function | The worst value of the objective function |
|---|---|---|
| 1.7468 | 1.3473 | 2.7235 |

## 5 Discussion and conclusion

This study aimed to optimize the quality of internal controls of companies listed on the Iranian Stock Exchange using the imperialist competitive algorithm. Improving internal controls can lead to the growth and profitability of these firms, given the importance of the stock market and its role in advancing and developing the country. According to the results of the imperialist competitive algorithm, the value of 2.73535 reductions of the quality of internal controls was obtained for the objective function five times the implementation of this algorithm in the first implementation in the 1340th iteration. The values of 2.5957, 1.9271, 1.404, and 1.3473 were, respectively, related to the second implementation (1356th iteration), third implementation (1371th iteration), fourth implementation (1400th iteration), and fifth implementation (1550th iteration). These results indicated the least possible error in the quality of internal controls and the most optimal value of internal control quality. The novelty of this study compared to other studies related to internal controls is that the model was obtained using qualitative-quantitative or mixed research, and it is not just qualitative or quantitative. Since the excellence of listed companies is to achieve maximum quality in internal controls, no study has been done in this regard, and most previous studies have focused on the relationships and effects of different variables with internal controls. However, this study tried to optimize the quality level of internal controls in companies listed on the Iranian Stock Exchange.

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