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Presenting an Optimization Model for Human Resource Management Audit Knowledge Based on Genetic Algorithms

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ABSTRACT

The aim of this research was to present an optimization model for a human resource management audit based on a genetic algorithm. This study is exploratory in nature due to the presentation of the model, and because its results are utilized by users, it is also considered practical. The Non-Dominated Sorting Genetic Algorithm II (NSGA-II) was employed as a meta-heuristic method to solve nine simulation problems. The results obtained from this method were then compared with those from the epsilon constraint method. The relationship between the results indicates that the NSGA-II algorithm is capable of reaching optimal solutions in a shorter time compared to the epsilon method, although it has specific limitations when applied to large-scale problems. The results of solving the proposed mathematical model were demonstrated through nine simulations using the desired algorithms, which were implemented in GAMS and MATLAB software. The model considered in this research is a bi-objective model aimed at minimizing inter-cell movements and human resource management audit actions (cell formation), while maximizing the relationships among management audit operators, taking into account network considerations and the efficiency of operators in human resource allocation. This model not only enhances the efficiency of human resource management but also offers the flexibility to adapt to various organizational challenges by providing a new and effective approach. Therefore, the application of this optimization model can significantly improve performance and efficiency in human resource management, contributing to development and progress within the organizational environment. **©authors**.

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1. Introduction

The human resource management audit knowledge optimization model emphasizes the significance of utilizing accurate data and advanced analytical methods to enhance decision-making processes within the realm of human resource management (Zambon et al., 2019). This model is founded on three primary principles: employee data analysis, optimization of audit processes, and enhancement of audit knowledge and skills (Iacuzzi et al., 2023). In the analysis of employee data, the application of advanced analytical tools, such as artificial intelligence and machine learning, enables managers to identify behavioral, functional, and interactive patterns among employees, allowing for necessary improvements in human resource management processes (Sauer et al., 2023). During the optimization phase of audit processes, the primary objective is to develop automated and intelligent systems for data collection, analysis, and reporting (Zhang et al., 2023). These systems enhance the audit process by minimizing human errors and increasing the accuracy of information analysis (Van Buren, 2020). Furthermore, this model underscores the necessity for audit processes to be designed for the continuous integration of new data to improve performance and reduce costs (Maley, 2024). Lastly, the enhancement of audit knowledge and skills constitutes another crucial element of this model (Zhang et al., 2023). Through training and professional development programs, HR auditors can stay current with data analysis techniques, emerging technologies, and innovative methodologies (Grossi et al., 2023). This ongoing education enables them to evaluate and enhance organizational performance more effectively and to contribute meaningfully to strategic decision-making (Chiucchi et al., 2022). Genetic algorithms and meta-heuristics in human resource management accounting, based on organizational data, play a vital role in optimization and strategic decision-making (Ni Wayan et al., 2021). These algorithms are particularly beneficial in scenarios where organizational data is complex and non-linear (Osama et al., 2012). By emulating natural selection and evolutionary processes, genetic algorithms identify optimal solutions from a range of alternatives. These algorithms can be applied in human resource management accounting to optimize resource allocation, formulate reward strategies, and assess employee performance (Pourkhodabakhsh et al., 2023).

On the other hand, meta-heuristic algorithms, including methods such as particle swarm optimization and simulated annealing, are employed to address complex problems and multi-objective optimization in human resource management accounting (Arora et al., 2023). These algorithms assist managers in making informed decisions in areas such as performance management, workforce planning, and the optimization of human resource costs by utilizing both historical and real-time data. The application of these algorithms in human resource management accounting enables organizations to leverage available data more effectively, thereby enhancing decision-making processes. By analyzing intricate data sets and developing predictive models, these algorithms empower organizations to optimize their performance and align more closely with their strategic objectives (Zhou et al., 2022). Consequently, it can be asserted that the optimization of human resource management audit knowledge through genetic algorithms is recognized as a scientific necessity in today's world. The increasing complexity of work environments and the rapid evolution of organizational needs and expectations have compelled managers to adopt more advanced tools for decision-making and process optimization. Genetic algorithms serve as an efficient tool in human resource management audits due to their distinctive capability to search for optimal solutions within vast and complex problem spaces (Margherita, 2022). By mimicking natural processes such as selection and evolution, these algorithms can achieve increasingly optimal solutions over time, which is particularly crucial in areas

like resource allocation and employee performance evaluation (Rijamampianina, 2015). Moreover, genetic algorithms facilitate the processing and analysis of substantial amounts of data (Wang et al., 2021). Organizations today contend with extensive HR data encompassing information about employee performance, behavior, and interactions. Utilizing genetic algorithms to analyze this data enables manager to uncover hidden patterns, which can inform better decision-making in human resource management (Gupta, 2018). This type of analysis can reveal factors that directly influence the enhancement of organizational performance, ultimately contributing to increased productivity and reduced human resource costs. Additionally, the application of genetic algorithms in optimizing human resource audits is vital due to their high flexibility. These algorithms can be updated in response to ongoing changes in organizational data and management requirements, providing optimal solutions that align with new conditions. This adaptability allows managers to dynamically enhance organizational performance by responding to environmental changes and leveraging their competitive advantage in the market (Zhao et al., 2020).

Genetic algorithms facilitate the development of predictive models and various scenarios. This capability enables organizations to evaluate the outcomes of different decisions prior to implementation, allowing them to select the most effective strategies. In the context of human resource management audits, such an approach can significantly reduce risks and enhance decision-making accuracy. The scientific imperative for optimizing knowledge in human resource management audits through genetic algorithms stems not only from their ability to analyze complex and multifaceted data but also from their flexibility and efficiency in adapting to environmental changes and organizational needs.

This optimization can empower organizations to make more precise and effective decisions in human resource management by leveraging advanced technologies, ultimately leading to improved overall organizational performance. This research seeks to answer the question: What is the pattern of optimizing human resource management audit knowledge based on genetic algorithms?

Accounting Knowledge in Human Resource Management

Human resource management audit knowledge encompasses a set of methods and processes used to evaluate and review the effectiveness, efficiency, and compliance of human resource performance with organizational goals and strategies. This knowledge enables managers to assess activities related to human resources, such as recruitment, training, development, and employee retention, ensuring that these activities are conducted optimally and in accordance with organizational policies and regulations.

Additionally, human resource management audits help identify weaknesses and opportunities for improvement in human resource processes, providing recommendations for enhancement (Totah, 2020). Furthermore, understanding human resource management audits allows organizations to identify and manage risks associated with human resources (Ullah et al., 2020; Singh and Gulati, 2021).

This knowledge employs analytical and reporting tools to present a clear picture of the organization's HR status, facilitating strategic decision-making and the continuous improvement of HR processes. Ultimately, auditing human resource management not only enhances organizational productivity and efficiency but also plays a crucial role in fostering a strong and stable organizational culture (Bora, 2023).

Genetic Algorithm

A genetic algorithm is a computational method based on the principles of natural evolution and natural selection, utilized to solve complex optimization problems and search within large solution spaces. Inspired by biological processes such as reproduction, mutation, and natural selection, this algorithm seeks to identify the best solutions from a population of potential candidates (Nayeri et al., 2022). In this framework, each

solution is treated as an individual within the population and is evaluated using a fitness function. The most effective solutions are selected and then randomly combined or mutated to generate a new generation of solutions. This iterative process continues until an optimal solution is found or a predetermined stopping condition is met (Kim et al., 2021). Genetic algorithms are applied across various fields, including engineering, artificial intelligence, economics, and life sciences. Because these algorithms search in parallel and progressively converge on superior solutions, they are particularly effective in addressing nonlinear and multidimensional problems characterized by large and complex search spaces. Genetic algorithms are especially advantageous when the search space is highly intricate or unknown, and traditional optimization methods fail to yield satisfactory solutions (Guerrero Granados et al., 2024). Given the significance of identifying human resources accounting, previous studies have either approached the topic differently or have been conducted with limited objectives, which will be discussed further in the following sections.

Table 1. *Summary of Internal and External Background*

Researcher/ Year	Title	Research method	Research findings
Adegbibe et al. (2024)	Human resource accounting and financial performance of listed money deposit banks in Nigeria	Regression analysis	The results showed that the cost of employee bonuses to income has a negative and significant effect on the return on capital employed in depositing money in banks in Nigeria. Also, employee cost and safety have a positive and significant effect on return on capital employed of listed money deposit banks in Nigeria. Employee retirement benefits have a negative and significant effect on return on capital employed of money deposit banks in Nigeria.
Olabi et al. (2024)	Human resource management in the health care system: recruiting, retaining and developing the workforce	Review	This article examines evidence-based human resource strategies, the role of technology and innovation, and future directions for human resource management in the healthcare sector. Key findings emphasize the need for comprehensive recruitment and retention programs, investment in professional development, and technology adoption to improve HR practices. Implications for health care human resource policy and practice are discussed, with recommendations for future research to increase the effectiveness of human resource management in health care settings.
Handiani et al. (2024)	The effect of employment, work culture and work environment on the quality of human resources	Solidarity	The obtained results showed that the variables of employment, work culture, work environment have a significant effect on the quality of human resources.
Agarwal (2023)	A Study of Human Resource Accounting Disclosures in Selected Public and Private Sector Companies in India	Review	They showed that human resource accounting is basically similar to financial accounting, that is, as financial accounting reflects the costs of assets such as buildings and machines, it shows human resources as capital and not as a cost. Therefore, investment shows the organization on its people and how their values change over a period of time.
Ozkan (2022)	The role of human resource accounting in the business environment	Content analysis	The results of the content analysis show that between 2010 and 2017, there is a growing trend in the disclosure of human capital by the banks listed in Bursa Istanbul, which indicates that the banks listed in Bursa Istanbul have become more aware of the importance of human capital.
Ogundajo et al. (2022)	Disclosure of human resources accounting information and company value	Ex-Post Facto research	Data analysis revealed that disclosure of employee training and development has a significant impact on form value. In essence, this study concluded that HR accounting disclosures have a significant impact on firm value.
Dobresco et al. (2021)	Human resource audit - a driver for sustainability in the health care system. Evidence from Romania	A systematic review	The results showed that a sustainable medical system not only supports costs, but also improves quality in the long term. Also, the sustainable strategy to maintain the medical staff, especially in incomplete medical specialties, the good cooperation of hospitals and higher education institutions in the field of training and development of human resources in this field has been mentioned as one of the important factors in achieving the sustainability of the health system.
Khan (2021)	The impact of human resource accounting on the financial performance of SME organizations	structural equations	SMEs in Saudi Arabia are aware of the benefits of human resource accounting and the only concern is that there is a need for quick management actions that can be made possible by widespread notification throughout the country. However, HR accounting has no significant effect on return on assets.

Haji Rezaei et al. (2024)	Presenting a model of comprehensive evaluation of human resource accounting through foundation data theory and metacombination in pharmaceutical companies	Grounded theory	In the discussion of causal conditions to components such as expertise and technical information, Galatea effect, experiences and learnings, the level of analytical power, cultural decision-making, psychological abnormality and in background conditions to demographic variables, policies, social relations and in intermediate conditions to productivity, competence Professional, awareness of the current issues of the organization.
Jafari Alamdari et al. (2024)	Human resources accounting and reporting based on metacognitive test with the future development approach of companies' reporting	PLS statistical software and fuzzy model (Text)	The findings show that all metacognitive factors (supervision of understanding, design and planning, error correction strategy, evaluation, information management, expressive knowledge, procedural knowledge, conditional knowledge) and the empowerment of financial managers have a significant relationship on the future development of human resources reporting.
Waqfi et al. (2023)	Identifying obstacles to the establishment of human resources accounting system based on Dimtel technique (case study: Mashhad University of Medical Sciences and its subsidiaries)	Demetel decision making technique and MATLAB software	The results of the research showed that expertise and skill can be one of the most important influencing factors in the accounting system, so this research, by presenting the obstacles and modeling factors of human resources accounting in the University of Medical Sciences, can be effective for better planning in recruitment and also in financial reports.
Ehtishami Nesab et al. (2023)	Representation of human resource accounting indicators in the telecommunications industry	Qualitative and quantitative	The findings showed that the human resources accounting model consists of six components; severance fee; Cultivating human resources; cost of recruitment, selection and recruitment; employee qualifications; Human resource information system and performance management process and service compensation. Therefore, by using the identified indicators in infrastructure communication, it is possible to improve human resource accounting.
Ramyar & Mohammadi (2023)	The impact of human resource accounting on the financial performance of organizations in the context of companies active in the Tehran Stock Exchange	Eviews	The results of the research have shown that human resource accounting has an impact on the financial performance (return on assets) of companies. Human resource accounting has an impact on the financial performance (return on equity) of companies. Human resource accounting has an impact on the financial performance of companies
Montazeri et al. (2022)	Designing the human resources audit model with the approach of macro and task level strategies using the cognitive mapping method in the social security organization.	Qualitative content analysis and one-step fuzzy Delphi method and cognitive mapping	The obtained model includes the categories of intellectual and mental ability, mental and psychological abilities, interaction skills, assignment skills, scientific abilities, organizational skills, thinking skills, supervision skills, occupational and professional skills, individual skills, interpersonal skills, strategic skills and management skills.

The proposed genetic algorithm in human resource management addresses several key challenges related to the optimization of workforce management. Here's a breakdown of the problems it solves based on knowledge and data-driven insights:

One of the significant challenges in HR management is identifying and aligning the right employees with the right tasks based on their skills, experience, and potential. Traditional methods often fall short in providing an optimal balance, leading to inefficiencies in productivity, employee dissatisfaction, and resource wastage.

Genetic algorithms solve this by analyzing large sets of data, including employee skills, experiences, and performance metrics, to find the most optimal workforce combination. The algorithm simulates different workforce scenarios and evolves the solution towards the best match between employees and organizational needs, ensuring optimal use of human resources and better task-role alignment.

Evaluating employee performance accurately is complex and often subject to bias or inconsistency. Traditional methods may overlook important patterns or factors that contribute to an employee's long-term potential and performance.

The genetic algorithm processes vast data from performance appraisals, feedback, and other employee-related data to identify hidden patterns in employee behavior and performance. By simulating and optimizing various scenarios, it helps managers make

more informed decisions regarding promotions, training, and role assignments, leading to a fairer and more accurate evaluation system.

Organizations struggle with predicting their future workforce needs based on changing market dynamics, organizational growth, or evolving skill requirements. Poor forecasting can lead to either a surplus or shortage of employees, causing inefficiencies.

Genetic algorithms analyze historical HR data to predict future workforce needs. The algorithm identifies trends and patterns, providing forecasts on the number of employees required, the skills in demand, and potential gaps. This helps organizations plan their recruitment, training, and development activities more effectively, ensuring a better match between supply and demand in the workforce.

Managing human resources can be costly, with expenses related to recruitment, training, employee retention, and turnover. Many organizations struggle to balance between cost reduction and maintaining high-quality human capital.

The genetic algorithm helps optimize HR-related costs by simulating various scenarios of workforce configurations, training programs, and retention strategies. By evolving towards the most cost-effective solution, the algorithm enables organizations to minimize costs while ensuring optimal performance and employee satisfaction.

Human resource management involves handling complex and large volumes of data related to employee attributes, performance, training, and organizational needs. Manual processing of this data is often inefficient and prone to error.

Genetic algorithms are specifically designed to handle large data volumes and complex optimization problems. In HR, they can process diverse datasets (such as employee histories, performance metrics, and market trends) to identify optimal solutions for workforce management, addressing issues that are beyond the capacity of traditional methods.

Human resource environments are dynamic, with rapid changes in technology, market conditions, and organizational strategies. HR managers must deal with these uncertainties while maintaining an effective workforce strategy.

Genetic algorithms, by nature, are adaptive and capable of responding to changing environments. They continuously evolve and improve solutions over time, meaning HR managers can use them to adjust workforce plans in response to new developments, ensuring the organization remains agile and competitive.

The proposed genetic algorithm, based on knowledge and data analysis, solves the critical problem of managing human resources more efficiently by:

- Optimizing workforce composition.
- Enhancing performance evaluations.
- Predicting future workforce needs.
- Reducing HR management costs.
- Managing complexity in large datasets.
- Adapting to changing organizational environments.

Through these solutions, genetic algorithms improve decision-making and operational efficiency in human resource management.

3. Method

The present research is exploratory in nature due to the introduction of the model, and because its results are utilized by users, it is also considered practical. This study employs a quantitative method to enhance the audit knowledge of human resource management. In the initial phase, effective components were identified through a literature review and document analysis, followed by modeling using mathematical programming techniques. The proposed model is optimized using GAMS software with the epsilon constraint algorithm, as well as MATLAB software employing the Non-Dominated Sorting Genetic Algorithm II (NSGA-II). The research focuses on a case study involving documents and articles related to education. The problem is formulated based on the following assumptions: the number of cells (human resource processes) is predetermined; the number of artificial intelligence operations is known; specific types of management accounting are identified, and the possibility of multiple human resource processes exists,

with their associated costs being known. There are no capacity limits for any type of management accounting. Each HR process operation can be managed by at least one type of management accounting. Each human resources operator is assigned to only one management accounting operator. For each cell, there is a limited capacity regarding the number of management accounting assignments. The cost of each unit of intercellular transport is fixed across all management accounting types and is independent of external conditions. The indices of the model are defined as follows:

p index related to management accounting *(p=1,2, 3,...,P)*

j index related to the operation *(j=1,2, 3,...,J)*

m index related to human resources *(m=1,2, 3,...,M)*

c index related to cells (market) *(c=1,2, 3,...,C)*

w index of operators *(w=1,2, 3,...,W)*

Input parameters

The efficiency of the operator *w* on the monotony ef_{wm}

If the *j*th operation of management accounting *p* can be processed on the human resources operator *m* 1 r_{pjm}= 1

Otherwise 0

Maximum number in cell *c* ub_c

Cost of inter-cell movement $^{inter\ cell}\gamma$

The relationship between the two operators *w* and *w'* $t_{ww'} \in [-5,5]$

Management accounting purchase cost $\propto_m$ *m*

Definition of problem variables

If operation *j* artificial intelligence *p* is performed on management accounting *m* in cell *c* X_{pjmc}= 1

Otherwise 0

Assign *w* operator to management accounting *m* in cell *c*. A_{wmc}= 1

Otherwise 0

Management accounting *m* should be assigned to cell *c*. N*mc* = 1

Otherwise

Mathematical Modeling

$$Min\ z_1 = \gamma^{inter\ cell} * \sum_{p=1}^{P}\sum_{j=1}^{J-1}\sum_{m=1}^{M}\sum_{\substack{m'=1\\ m\neq m'}}^{M}\sum_{c=1}^{C}\sum_{\substack{c'=1\\ c\neq c'}}^{C}\left(X_{pjmc} * X_{p(j+1)m'c'}\right) + \sum_{m=1}^{M}\sum_{c=1}^{C} \propto_m * N_{mc} \quad (1)$$

$$Max\ z_2 = 0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2}\sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c} \quad (2)$$

St.

$$X_{pjmc} \leq N_{mc}\ \forall\ \ p = 1,2,\dots,P,\ \ j = 1,2,\dots,J,\ \ m = 1,2,\dots,M,\ \ c = 1,2,\dots,C \quad (3)$$

$$\sum_{m=1}^{M} N_{mc} \leq ub_c\ \forall\ \ \ c = 1,2,\dots,C \quad (4)$$

$$\sum_{m=1}^{M}\sum_{c=1}^{C} A_{wmc} = 1\ \forall\ w = 1,2,\dots,W \quad (5)$$

$$\sum_{m=1}^{M}\sum_{c=1}^{C} X_{pjmc} = 1 \; \forall \; p = 1‚2‚ \dots TP \; ‚ \quad j = 1‚2‚ \dots ‚J \tag{6}$$

In the first objective function (1), the goal is to minimize the total time and costs associated with management accounting. The first term, $\gamma^{inter\ cell}$, represents the time cost incurred when two consecutive operations are not performed within a single management accounting process. The second term, $\propto_m$, denotes the purchase cost for each management accounting operation.

The second objective function (2) aims to maximize the overall efficiency of human resource operators and their compatibility with the with the matching coefficient model. The first term reflects the efficiency of artificial intelligence operators in managing human resources for accounting, while the second term assesses the compatibility of human resource operators within a network framework.

Constraint (3) states that operation j of part p can only be performed by management accounting operator m if at least one management accounting operator m is assigned to human resources operation *c*.

Constraint (4) specifies the maximum number of management accounting operators allowed in each human resources operation.

Constraint (5) ensures that each management accounting operator is assigned to only one human resources operation.

Finally, Constraint (6) stipulates that each management accounting operator can only perform one process within a single operation. The proposed model is analyzed using the epsilon constraint technique to address multi-objective problems, implemented in GAMS and MATLAB software.

4. Finding

This section investigates the solution to the presented model by conducting nine simulations of the problem. It includes a comprehensive solution for a medium-scale test problem and an evaluation of the results. The model is analyzed using GAMS software with the epsilon constraint algorithm, as well as MATLAB software with the Non-Dominated Sorting Genetic Algorithm II (NSGA-II). The simulations were executed on a personal computer equipped with an Intel® Core™ i5-3210M CPU running at 2.50 GHz and 4.00 GB of RAM. Finally, the model was validated using the sensitivity analysis method. The nine numerical simulations consist of three small-scale examples, three medium-scale examples, and three large-scale examples, with specifications detailed in Table 2 of the test problem. The results were analyzed using two epsilon limit algorithms and the NSGA-II.

Table 2. *9 Simulation of the problem*

Scale	*P*	*J*	*M*	*W*	*C*	*Upper Bound*	$\gamma^{inter\ cell}$	$\propto$	ε – constraint			$NSGA-II$		
									N	*MID*	*Time*	*N*	*MID*	*Time*
Small	5	*3-2*	5	8	3	*2-3-2*	10	*900-500*	3	0	61.75	3	0.86	69
Small	5	*4-2*	5	7	3	*2-3-3*	10	*900-400*	5	0	46.43	5	0.78	86
Small	5	*4-2*	5	8	3	*2-2-2*	12	*900-500*	5	0	42.35	6	1.03	112

Average	10	6-2	10	15	3	2-3-4	10	900-500	5	0	14305.21	4	0.64	164
Average	11	6-2	10	15	3	4-4-4	12	900-500	6	0	23629.07	12	0.89	563
Average	12	6-2	10	15	3	4-3-3	10	900-500	4	0-34%	78982.55	5	0.92	174
Big	15	7-2	15	20	3	4-5-6	15	1100-800	4	34%-86%	217424.82	3	0.84	215
Big	25	8-2	15	25	3	4-10-8	12	1100-500	3	67%-128%	218348.37	6	0.97	237
Big	40	9-2	20	30	3	10-6-9	15	1400-800	2	87%-194%	220393.61	9	0.73	261

This problem with the number of 12 human resources and 2-6 artificial intelligence operations for each management accounting, the number of operations for each part is given in Table 2, the number of operators in each human resources process, and 10 types of management accounting, 15 operators and 3 cells, which are the capacity of the cells. In table 4, the capacity of the cells is mentioned, and the input data of the problem is given in table 4, the ability to perform the operator by management accounting, table 5, the efficiency of operators on human resource management, and table 6, the cost of infrastructure provision.

Table 3. *The number of operations of each HR process*

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
2	4	6	2	5	6	5	5	5	6	3	5

Table 4. *Capacity of cells*

Cell 1	Cell 2	Cell 3
3	*3*	*4*

Table 4. *Ability to perform the operator by management accounting*

p.j m	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1.1	1	0	0	1	1	1	0	1	1	0
1.2	1	1	0	1	0	0	1	1	0	1
2.1	1	0	1	1	0	0	0	0	0	0
2.2	1	0	1	1	1	1	1	0	1	1
2.3	1	1	0	1	0	1	1	1	1	0
2.4	1	1	1	1	0	1	1	1	0	0
3.1	1	0	0	1	1	0	0	1	1	0
3.2	0	1	1	1	1	1	1	1	0	0
3.3	1	1	1	1	0	0	0	0	1	1
3.4	0	1	1	1	1	0	1	1	0	1
3.5	0	0	0	0	0	0	1	1	1	0
3.6	1	0	0	1	1	1	1	0	0	0
4.1	0	0	0	0	0	1	1	1	0	1
4.2	0	0	0	1	1	0	1	0	0	0
5.1	1	1	1	0	1	1	1	1	1	1

5.2	0	0	0	1	0	0	1	1	0	0
5.3	1	0	0	0	1	1	0	0	1	1
5.4	1	0	1	1	1	0	0	1	0	1
5.5	1	0	0	0	0	0	0	0	0	0
6.1	0	1	0	1	1	0	0	1	1	1
6.2	1	0	1	1	1	1	0	1	0	0
6.3	1	1	1	0	0	1	0	1	1	0
6.4	0	1	1	1	1	0	1	1	1	1
6.5	1	1	0	0	0	1	1	0	0	0
6.6	0	1	1	0	1	1	0	1	1	0
7.1	0	0	0	1	0	0	1	1	0	0
7.2	1	0	1	1	0	0	0	1	0	1
7.3	0	0	1	1	0	0	0	1	1	0
7.4	1	1	1	1	1	0	1	1	1	1
7.5	1	0	1	0	1	1	0	1	1	1
8.1	1	1	0	1	0	0	1	1	1	1
8.2	1	0	0	1	0	1	1	1	0	1
8.3	0	0	0	0	0	0	0	0	1	1
8.4	1	1	1	0	1	0	0	1	0	1
8.5	1	1	1	1	1	0	1	1	1	1
9.1	0	1	0	0	0	1	0	1	1	0
9.2	1	0	0	1	0	1	1	1	1	0
9.3	0	1	1	1	1	0	0	1	1	0
9.4	1	0	0	1	0	0	1	0	0	1
9.5	1	0	0	0	0	0	1	0	1	1
10.1	0	0	0	0	1	0	0	1	1	1
10.2	0	0	1	0	1	0	1	1	0	1
10.3	0	0	1	1	1	1	1	1	1	1
10.4	0	0	0	0	1	1	0	0	0	1
10.5	0	0	1	0	1	1	1	0	1	1
10.6	0	1	0	1	0	1	0	1	0	1
11.1	0	0	0	1	0	0	1	1	1	0
11.2	1	1	0	0	0	1	0	1	0	1
11.3	0	0	0	0	1	0	0	1	0	0
12.1	1	0	0	0	0	1	0	0	0	0
12.2	1	0	0	1	1	1	0	1	0	1
12.3	1	0	0	1	1	1	0	1	1	0
12.4	1	1	0	0	0	0	0	1	1	1
12.5	0	0	1	0	1	1	0	1	1	1

Table 5. *Efficiency of operators on management accounting*

w ***w'***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	0	1	5	1	1	-2	2	3	-5	4	-4	-1	1	-3	5
2	1	0	-5	-4	1	4	-4	5	-5	2	-3	1	-4	-1	-5
3	5	-5	0	-5	4	3	-5	2	-5	-1	-3	-3	-4	4	-4
4	1	-4	-5	0	5	-2	-3	-4	-3	-4	-2	-5	3	-2	1
5	1	1	4	5	0	-1	5	-1	0	3	2	5	-4	1	-2
6	-2	4	3	-2	-1	0	3	2	-5	3	-2	2	-4	4	-2
7	2	-4	-5	-3	5	3	0	-5	-3	2	-2	2	-2	-2	-5
8	3	5	2	-4	-1	2	-5	0	-2	2	0	5	-3	2	-4
9	-5	-5	-5	-3	0	-5	-3	-2	0	3	-2	1	0	5	-2
10	4	2	-1	-4	3	3	2	2	3	0	0	-2	-5	2	-1
11	-4	-3	-3	-2	2	-2	-2	0	-2	0	0	2	1	1	-2
12	-1	1	-3	-5	5	2	2	5	1	-2	2	0	-1	5	-3
13	1	-4	-4	3	-4	-4	-2	-3	0	-5	1	-1	0	-5	-1
14	-3	-1	4	-2	1	4	-2	2	5	2	1	5	-5	0	3
15	5	-5	-4	1	-2	-2	-5	-4	-2	-1	-2	-3	-1	3	0

Table 6. *Efficiency of operators on management accounting*

wm	1	2	3	4	5	6	7	8	9	10
1	0.62	0.51	0.68	0.49	0.78	0.52	0.27	0.81	0.56	0.11
2	0.85	0.78	0.83	0.37	0.56	0.34	0.21	0.57	0.42	0.83
3	0.30	0.20	0.28	0.77	0.63	0.22	0.24	0.11	0.19	0.88
4	0.54	0.60	0.84	0.48	0.63	0.04	0.12	0.64	0.48	0.42
5	0.19	0.96	0.76	0.27	0.86	0.33	0.16	0.74	0.72	0.52
6	0.55	0.39	0.99	0.01	0.36	0.89	0.03	0.64	0.23	0.38
7	0.53	0.41	0.89	0.99	0.27	0.70	0.64	0.76	0.04	0.41
8	0.44	0.15	0.91	0.11	0.42	0.53	0.67	0.01	0.83	0.79
9	0.99	0.48	0.25	0.63	0.20	0.93	0.79	0.09	0.54	0.94
10	0.39	0.83	0.00	0.59	0.55	0.39	0.12	0.63	0.05	0.23
11	0.22	0.60	0.52	0.36	0.82	0.23	0.94	0.83	0.64	0.03
12	0.86	0.04	0.71	0.00	0.70	0.01	0.95	0.02	0.72	0.54
13	0.03	0.66	0.96	0.28	0.53	0.33	0.01	0.67	0.09	0.03
14	0.83	0.46	0.13	0.80	0.62	0.96	0.45	0.29	0.55	0.07
15	0.39	0.28	0.55	0.51	0.34	0.69	0.55	0.69	0.21	0.07

Table 7. *Infrastructure procurement cost*

m	1	2	3	4	5	6	7	8	9	10
price (m)	697	684	861	586	706	744	627	779	698	886

We take the above data into the problem and solve the problem once for the second objective function and again obtain the second objective function for the optimal value of the first objective function and the answer obtained from the software is equal to:

Table 8. *Efficiency table obtained from the optimization method*

	f_1	f_2
Min f_1	-	-0.887
Min f_2	-	41.0215

Now we get the difference of the above two answers and divide by five as explained in the methodology, and the restrictions added to the problem are as follows:

$$0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2} * \sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c} \geq 41.0215$$

$$0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2} * \sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c}$$

$$0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2} * \sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c}$$

$$0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2} * \sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c}$$

$$0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2} * \sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c}$$

$$0.55 * \sum_{w=1}^{W}\sum_{m=1}^{M}\sum_{c=1}^{C}(A_{wmc} * ef_{wm}) + 0.45 * \frac{1}{2} * \sum_{w=1}^{W}\sum_{\substack{w'=1\\ w\neq w'}}^{W}\sum_{c=1}^{C} t_{ww'} * \sum_{m=1}^{M} A_{wmc} * \sum_{m=1}^{M} A_{w'm'c}$$

The main problem has been solved six times with one of these constraints, and their solutions have created the Pareto diagram, which is shown in Figure 1:

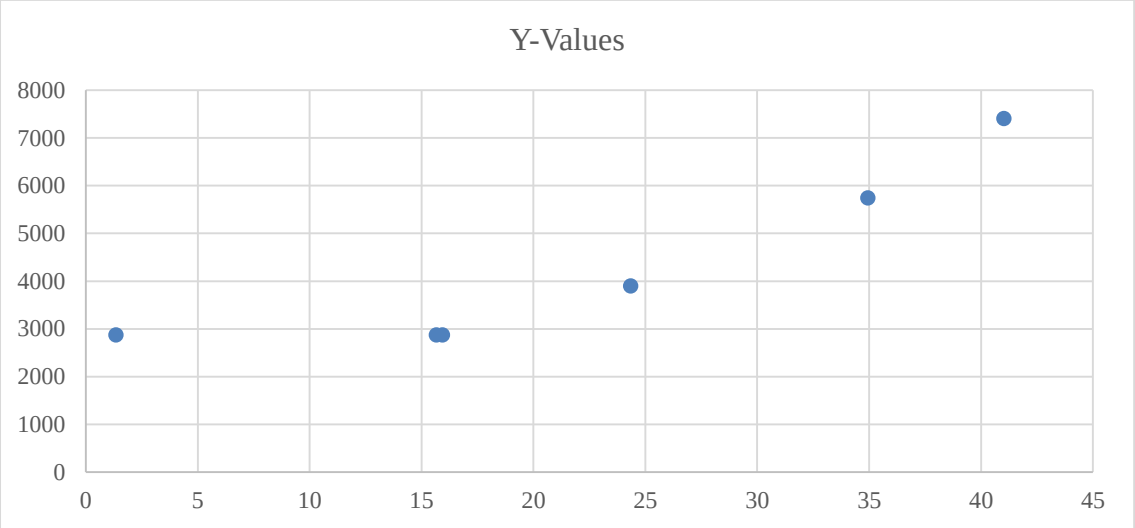

Figure 1. *Pareto diagram of problem solving*

5. Discussion

Human Resource Accounting Audit is a managerial approach that evaluates and measures an organization's human resources. This field seeks to identify both the financial and non-financial value of human capital as one of the most critical assets of an organization and assesses its impact on overall productivity and performance. In other words, human resource auditing helps clarify and measure the costs and benefits associated with the workforce, enabling managers to make more informed decisions to improve performance, increase productivity, and better manage human resources.

One of the main challenges in human resource auditing is the complexity and vastness of information related to human capital. For example, evaluating factors such as employees' skills, experiences, and motivations is difficult to achieve through traditional methods. Therefore, intelligent and technology-based tools, such as genetic algorithms, have been suggested to improve accuracy and efficiency in analyzing this data. Genetic algorithms are optimization techniques inspired by natural evolution and evolutionary biology, used to solve complex problems. They utilize mechanisms like natural selection, mutation, combination, and selection to reach the optimal solution in complicated issues. Genetic algorithms simulate the evolutionary process of living organisms to provide the best possible solutions in various fields, including human resource management and auditing.

Genetic algorithms can be used in human resource auditing to optimize the workforce composition. This means they can help organizations identify the optimal combination of employees with the necessary skills, experiences, and characteristics and manage their human resources more efficiently. A genetic algorithm can analyze employee performance data and identify patterns showing which individuals will perform best in which roles. This allows HR managers to make better decisions about training, promotions, or task assignments. The findings of Sauer et al. (2023) confirm the effectiveness of such applications.

As results indicate, one of the key applications of genetic algorithms in human resource auditing is predicting future workforce needs. This algorithm can analyze past data, identify patterns, and forecast future human resource requirements, contributing to improved workforce planning. Human resource auditing involves assessing the costs associated with hiring, training, and retaining employees. Genetic algorithms can be used to identify the best strategies for cost reduction and optimize human

capital investment (Pourkhodabakhsh et al., 2023).

Genetic algorithms improve the accuracy of analyses by processing large amounts of data and identifying complex patterns. The use of this algorithm allows organizations to reach desired outcomes more quickly and optimize auditing processes. With genetic algorithms, organizations can make more accurate forecasts about their future workforce needs and create more effective development and management plans for their human resources. The results obtained were also confirmed by Chiucchi et al. (2022).

Human resource accounting audit, based on genetic algorithms, is an advanced and intelligent approach to improving human resource management. This method, through the use of smart optimization techniques, helps organizations offer an optimal workforce composition, more precise performance evaluation, and better predictions of future needs. The use of genetic algorithms in human resource auditing not only enhances accuracy and efficiency but also improves the ability to forecast and optimize human resources, ultimately leading to better organizational performance and increased productivity.

6. Conclusion

The purpose of this research was to develop a model for optimizing knowledge in human resource management audits. A mathematical model addressing the problem was presented and explained. Furthermore, the research utilized the epsilon constraint algorithm and the non-dominated sorting genetic algorithm (NSGA-II) as methods for solving the problem. The results obtained from solving the proposed mathematical model were illustrated through nine simulations conducted using these algorithms, implemented in GAMS and MATLAB software. The model considered in this research is a dual-objective framework aimed at minimizing inter-cell movements and management accounting (cell formation) while maximizing the relationships among human resource operators, taking into account network considerations and the efficiency of operators in management accounting (operator allocation). In organizational environments, the formation of cells and the examination of operational relationships are crucial. By presenting the audit knowledge model of human resource management, this research represents a significant step toward enhancing the performance and efficiency of human resources through a meta-heuristic approach. This model was developed using modern and effective algorithms, such as the epsilon constraint algorithm and NSGA-II, which provide organizational managers and human resource analysts with reliable tools for making optimal and informed decisions in a dynamic environment. This model not only enhances the efficiency of management accounting but also enables organizations to adapt to various challenges by offering a new and effective approach. Consequently, the application of this optimization model can contribute to improved performance and profitability within the organization, fostering development and progress in the human resources domain. In human resource environments, the formation of cells and the examination of operational relationships are of paramount importance due to their direct impact on performance and efficiency. Given the complexity and dynamic nature of the market, there is a need for patterns and optimization models that facilitate effective decision-making in the face of various challenges. This research aims to enhance the performance of management accounting in human resources by presenting a dual-purpose model and employing modern algorithms to address the problem.

This research can assist managers, analysts, and others interested in this field in making more optimal and informed decisions in response to the changing conditions within their organizations. Such improvements can enhance overall performance and efficiency in the market.

Practical suggestions for addressing the identified issues include assigning each operator to only one human resources (HR) process while allowing them to manage multiple management accounting tasks or even work across several cells. In this context, there is no capacity limit for each type of operator; however, the number of operations or the time allocated can be specified for each accounting operator. In this model, each operation is handled by a single operator, and there is no risk of task failure. Additionally, multiple management accountants can perform the same operation simultaneously. Integrating scheduling concepts with the challenges of cell formation and management accounting layout presents an intriguing area for further exploration. Furthermore, incorporating factors such as setup time, installation time, and the time value of money into the model's constraints could prove beneficial.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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