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ChatGPT Effects on 21st Century Skills of University Students: A Systematic Seview

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Abstract
This study was carried out to investigate effects of ChatGPT on 21st century skills of university students. Since there are several 21st century skills, the study focused on only five (i.e. critical thinking, communication, collaboration, creativity, and problem-solving skills). The study employed systematic review of literature in which PRISMA framework was employed to facilitate selection of studies included in the review. Findings revealed that ChatGPT poses effects to students on each of the 21st century skills. However, the type and magnitude of effects depends on the type of skill. ChatGPT was found to bring more positive impacts to university students' communication skills while more negative impacts on collaboration skills. While that was the case, the study found that ChatGPT can bring either positive or negative impacts on critical thinking, creativity and problem-solving skills. The effects depend mainly on the magnitude of students' dependency on it. Those that depend more on it are likely to be more negatively affected. For instance, the more the students depend on ChatGPT, the less the ability for them to think critically and solve problems. The study recommends, therefore, that universities should embrace ChatGPT instead of avoiding it. However, they should strive to implement mechanisms such as establishing relevant guidelines as well as instituting AI literacy programs that help to reduce students' over-reliance on it, among others.

Keywords: *ChatGPT, University Students, 21st century skills, Higher Education Institutions*

Introduction

For years, Higher Education Institutions (HEIs) focused on traditional academic knowledge which equipped students with attitude, skills and knowledge within their domains of study (Cervantes, 2017). However, the labour market requirements have significantly changed. The 21st century brought an era of novel aspects, unlimited possibilities, and state-of-the-art innovations in the labour market. Employers are increasingly value interdisciplinary competencies and skills that are not primarily based on students' content knowledge (Dede, 2010). A study by Kienzler et al. (2023) indicates that many workers are now engaged in jobs requiring critical thinking, problem-solving and complex communication skills. Such kinds of skills constitute some of the 21st century skills.

The concept of 21st century skills, according to Dilekçi and Karatay (2023), appeared for the first time in 2006 in the Organisation for Economic Co-operation and

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Development (OECD) project. The project, among other aims, defined skills that are expected to be possessed by people in the 21st century. It was indicated, in the project, that the 21st century demands special competences necessary for mastering every aspect of life in facing the challenges of uncertain prospects in the future. Along with OECD, many other institutions such as the World Economic Forum and the British Council have been involved in categorizing, teaching and testing 21st century skills in schools and universities (Kienzler et al., 2023). The United Nations Development Programme (UNDP) describes the following as some of 21st century skills: critical thinking, communication, collaboration, creativity, and problem-solving. Others are digital literacy, global citizenship and conflict management, flexibility and adaptability, and empathy and self-direction (UNDP, n.d.).

Studies show an increased use of ChatGPT, a general-purpose conversation chatbot-based Natural Language Processing (NLP) system that produces well-structured, logical, and informative responses that exhibit the response-generating ability of human beings (Duong et al., 2023), among university students (Urban et al., 2024; Hasanein & Sobaih, 2023; Romero-Rodríguez et al., 2023). Students use ChatGPT for several reasons. Most of such reasons are oriented to their educational undertakings. For instance, according to Matto (2024) and Firat (2023), most university students use ChatGPT for accessing resources for their personalized learning, interactive learning, and getting instant assistance in undertaking assignments. Consequently, previous works attempted to establish merits and detriments of the ChatGPT in students' learning process. However, most of them focus on students' classical knowledge domains (Youssef et al., 2024; Matto, 2022; Acosta-Enriquez et al., 2024; Duong et al., 2023; Hasanein & Sobaih, 2023). But, as said by Dede (2010), the present world demands more than traditional knowledge acquired through conventional courses. In fact, the world demands people who are well equipped with 21st century skills.

Unfortunately, the majority of previous scholars did not investigate the effects of ChatGPT on 21st century skills as a specific area of focus. Most prior studies that considered 21st century skills focused on only one skill at a time (see for example Urban et al., 2024; Harahap, 2024; Kim et al., 2024; Dempere et al., 2023; Toma & Yánez-Pérez, 2024; Swaraj Chavan, 2024; Romero-Rodríguez et al., 2023). This limits comparative analysis of effects of the tool on a wide range of skills, and thus, limited knowledge regarding which skill aligns better with ChatGPT as compared to others. It was against this backdrop the present study was carried out to investigate effects of ChatGPT on 21st century skills of university students. Since there are many 21st century skills, the study focused only on the following five: critical thinking, communication, collaboration, creativity, and problem-solving skills. The reasons for their choice were twofold. First, these are skills that ChatGPT can play a role in either supporting or destroying their acquisition, and second, they are among top 21st century skills listed by the majority of scholars (Dilekçi & Karatay, 2023 & Cleaves, 2015). Consequently, the study sought to answer the following key questions: What effects doe's regular interactions with ChatGPT have on

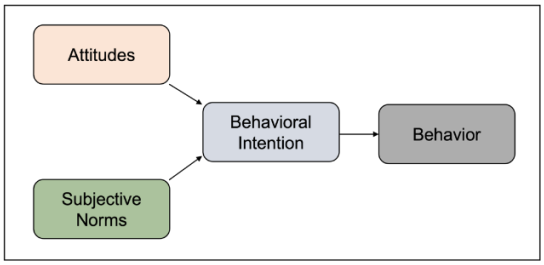
the students' critical thinking skills? How dependence on ChatGPT does affects communication skills among students? What impact does over-reliance on ChatGPT have on students' collaboration skills? In what ways does ChatGPT serve as a catalyst or barrier to creativity among university students? And, how does ChatGPT affect problem-solving skills of university students? Answering these questions underscores the potential impact of the study on educational practices.

Theoretical Framework

This study was informed by two theories: constructivism theory and the Theory of Reasoned Action (TRA). The constructivist theory claims that learners construct their own knowledge through engaging and not by being passive recipient of information (Lunenburg, 2011). Researchers such as Hasanein and Sobaih (2023) and Makewa (2019) suggest that ChatGPT provide opportunities to support the constructivist learning experience as it enables students to construct their own knowledge through asking it questions and getting instant response. However, on the other side, some scholars (see for example, Rasul et al. (2023)) posit that habitual use of ChatGPT hampers students' personal reflections on subject matters which are necessary in accomplishing the learning outcomes. If this happens, it will eventually have effects on the 21st century skills.

On its side, TRA explains the relationship between attitudes and behaviours within human action. It stipulates that a person's behaviour is determined by their behavioural intention and that such an intention is, in turn, a function of their attitude toward the behaviour and subjective norms (Fishbein and Ajzen, 1975). In this regard, TRA is made of four blocks: belief, attitude, subjective norms, behavioural intention, and behaviour, as shown in Figure 1. Attitude is the overall evaluation of the behaviour by the individual. For instance, if someone thinks that a certain action will lead to desirable outcomes, they will have a positive attitude toward it, and vice versa. Subjective norms consist of a person's beliefs about whether the important people in his/her life think he/she should engage in the behaviour. In other words, subjective norms suggest that attitudes are affected by beliefs. For instance, a young person may think they will seem cooler if they smoke. Behavioural intention is the readiness to perform a behaviour, in which the stronger the intention to perform the behaviour, the more likely the behaviour will be performed. In this case, attitudes and subjective norms affects behavioural intentions.

Figure 1.
The Theory of Reasoned Action (Source: Fishbein & Ajzen, 1975)

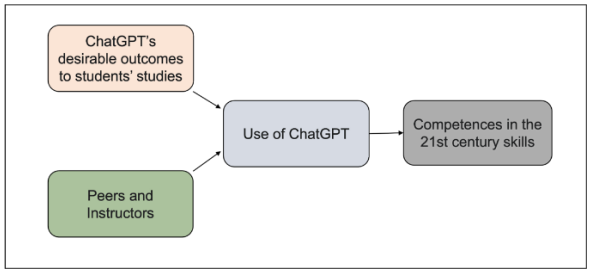


In a general view, TRA is mainly used to predict how individuals will behave based on their pre-existing attitudes and behavioural intentions. The theory can be applied in the present study's context in which competences in the 21st century skills (behaviours) are affected by the use of ChatGPT (behavioural intentions). In the same study's context attitudes are the

students' evaluation regarding the use of ChatGPT in their studies. In this case, students can be thought of believing that ChatGPT brings desirable outcomes in their learning and thus have a positive attitude towards it. And finally, subjective norms are student peers as well as instructors who believe that students should incorporate ChatGPT in their learning. Figure 2 shows a contextualised theory of reasoned action as per the focus of this study.

Figure 2.

Contextualized Theory of Reasoned Action



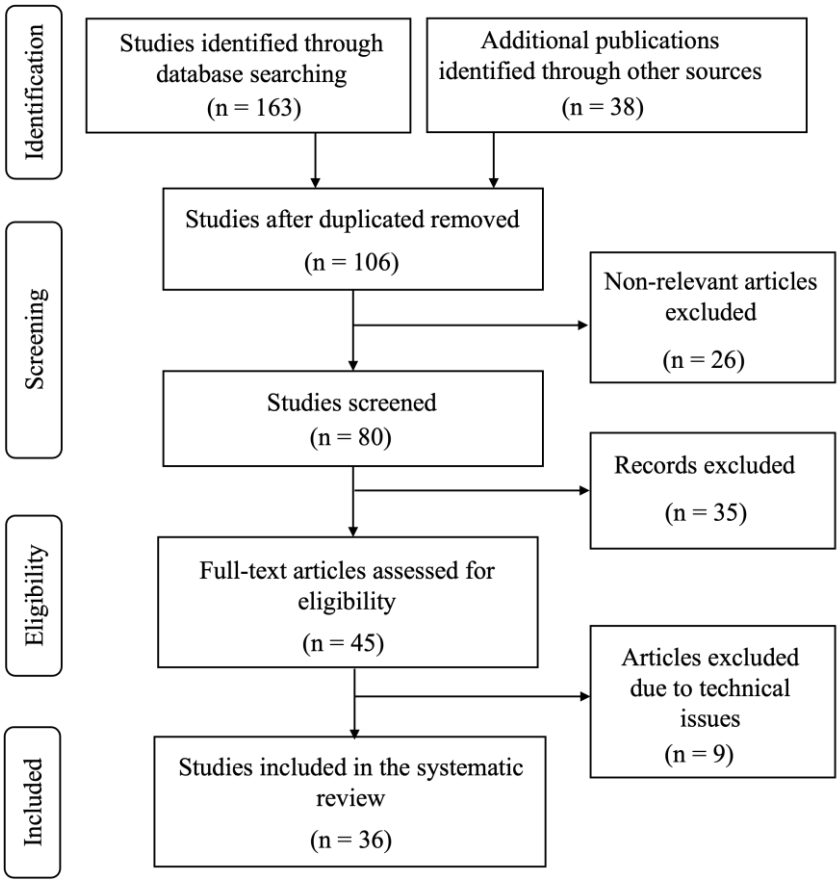
Methodology

The study was based on systematic literature review in which empirical evidence from existing studies regarding the effects of ChatGPT on the 21st century skills of university students was investigated. The literature that was used included journal articles, conference proceedings, reports, books, case studies, and informational web contents. A comprehensive search was conducted to obtain studies for review. The searching was done in existing databases including DOAJ, Google Scholar, JSTOR, EBSCO and Web of Science. Searching was also done to obtain publications from other sources including related informational websites. The search was performed using phrases related to the effects of ChatGPT on the 21st century skills of university students. The phrases included "ChatGPT" AND "university students" OR "Critical thinking" OR "communication skills" OR "collaboration skill" OR "creativity" OR "problem-Solving skills". The searching was limited to only English articles published within the past five years.

A total of 191 articles were identified from this search; 163 from databases and 38 from other sources. After removing duplicated articles, a total of 106 remained. A total of 26 articles were found to be irrelevant, thus excluded. After thorough screening of the remaining 80 articles, 35 were excluded because the study couldn't retrieve them in full. A total of 45 full-text articles were, thus, found to be eligible for analysis. However, 9 of them were found to have technical issues, therefore dropped. Thus, the final number of studies that were included in the review was 36 as summarized in a PRISMA framework in Figure 3. The content analysis approach was employed in the elected literature in which themes were extracted as per the five focused 21st century skills and main points from each theme were summarised. The results of the analysis were then presented and discussed in the results and discussions section.

Figure 3.

PRISMA framework showing inclusions and exclusions of reviewed articles



Results and Discussions

Critical thinking

With regard to the ChatGPT effects on university students' critical thinking skills, the study found mixed opinions among previous researchers. Some feel that the tool enhances critical thinking while others are of the opinion that it diminishes it. Emran et al. (2024), for instance, conducted a study that investigated the use of ChatGPT responses to 61 university students as a method to improve their critical thinking potentials among other skills. The study found that the program for using ChatGPT helped students improve their critical thinking skills. Similarly, a study by Guo & Lee (2023) which was also based on primary data from students' engagement with ChatGPT found that ChatGPT brings a significant improvement in students' critical thinking skills, especially when requiring them to dig into complex questions, analyse facts and draw logical conclusions. The authors, thus, recommended employment of ChatGPT as a tool for enhancing students' critical thinking. The same views were observed in Muniandy & Selvanathan (2024).

On the contrary, a study by Lo et al. (2024) which was based on a review of existing literature, raised concern that the growing use of ChatGPT declines students' critical thinking.This was said so because, as per the authors, many students do not fact-check and validate information produced by ChatGPT. Similarly, studies by Nicolas (2023) & Ferreira (2024), which is also based on a systematic literature review, supported by case studies and some semi-structured

interviews with teachers, found a major disadvantage of using ChatGPT for students is the potential for over-reliance on it, which can hinder their critical thinking and independent learning. Further, Krupp et al. (2024) highlighted missing reflection and limited critical thinking as two of the main issues when students use ChatGPT in education.

Although the contradicting perceptions could have been partly contributed by the methodological stances of the studies, but they generally imply that ChatGPT has the potential to either create or destroy critical thinking skills of university students. This is supported by Akastangga et al. (2023) and Hasanein & Sobaih (2023) who revealed a moderate effect of ChatGPT on students' critical thinking skills in which excessive dependence on ChatGPT is likely to reduce the level of critical thinking skills. Therefore, it is reasonable to suggest that it is important for university students to reduce over-reliance on ChatGPT and cultivate a culture of analytical reasoning. This can be achieved by deeply analysing information and embedding their own perspectives in the answers provided by ChatGPT.

Communication

Another fundamental competence that this study looked at was communication skills. The study findings revealed that, regarding communication skills, scholars consider ChatGPT is creating more positive than negative impacts to university students. For instance, Zhou et al. (2023) found that regular interactions with ChatGPT increase learners' competence to communicate. Likewise, as stated by Montenegro-Rueda et al. (2023), ChatGPT enhances students' written communications because by interacting with it, students receive grammatical corrections which improves their writing skills. ChatGPT was also found to improve students' mathematical communication skills (Septiani et al., 2024). Further, with its ability to provide real-time natural language interactions, ChatGPT not only assists in training students' communication skills but also prepares them to handle various international business situations (Mustafa and Ausat, 2024; Muniandy & Selvanathan, 2024). This finding is supported by Al Shloul et al. (2024) who found that students can improve their communication skills by using ChatGPT through having real chats with other students. According to the authors, this improves not only how they communicate but also skills to work with one another. The issue of working together is indicated also in Montenegro-Rueda et al. (2023) who asserted that ChatGPT excels in its ability to facilitate group discussions and promote collaborative student participation in projects and assignments.

While studies indicate positive impacts of ChatGPT in terms of improving students' communications skills, it is essential to understand that the tool should not be considered as a complete solution. The 21st century's communication skills go beyond writing, it is important for universities to consider other avenues in developing effective listening and speaking skills. As also said by Sinha & Sinha (2007) students need to be imparted with emotional awareness and management skills as part of improving their communication skills. In addition, the five w's and h of communication (i.e. who, what, when, where, why and how to communicate) cannot be developed by ChatGPT alone. Thus, while ChatGPT presents an opportunity to improve

communication skills to university students, there must be further complementary initiatives

Collaboration

Collaboration skill is essential to university students as it prepares them to become individuals who are capable of not only working with others but also able to learn from, share with, and express themselves in an effective way, which are essential ingredients of the 21st century skills (Cleaves, 2015). Although a majority of studies conducted to establish the contribution of ChatGPT in the building of collaboration skills to students showed that the tool is generally bringing more isolations than working together among students, some studies suggest the oppositr. Osman et al. (2024) & Aithal & Aithal (2023) for example, found that ChatGPT facilitates collaboration through virtual peer interactions by allowing students to engage in conversational exchanges that mimic real-life discussions. In so doing, as per the authors, the tool encourages students to collaborate, debate, and share assignments and ideas.

On the contrary, Rasul et al. (2023) found that students who interact primarily with ChatGPT, do not engage in collaborative learning and discussion. Similarly, according to Hasanein & Sobaih (2023), if ChatGPT becomes a primary source of learning and assistance, it brings a negative influence on students' social interaction in education. This is confirmed by a statistical analysis by Kim et al. (2024) which found that ChatGPT diminishes the level of active learning interactions between students, a crucial element for successful collaborative learning. This happens because depending on ChatGPT for learning guidance reduces opportunities for face-to-face interactions between students themselves and between students and their instructors. In turn, peer collaboration is discouraged resulting in less interpersonal communication and thus diminishing skills to collaborate. The less effectiveness in collaboration while at the university implies the same to students even after graduating (Delbanco, 2023) Most of the studies that highlighted the negative impacts of ChatGPT on collaboration skills underscored, however, that it happens only if there is overreliance on the tool.

Creativity

The findings of this study revealed a mixed feeling amongst scholars regarding the effects of ChatGPT in stirring-up creativity. Some feel that it has positive effects while others are on the opposite view. Regarding the positive impacts, a study by Toma & Yánez-Pérez (2024) which aimed at investigating the impact of using ChatGPT on undergraduates' creativity found no evidence that ChatGPT negatively affects creativity to students. In particular, the results showed that 53.57% of undergraduates who participated in it experienced improvement in their creativity upon using ChatGPT while 25% experienced decreased creativity. Likewise, a study by Swaraj and Chavan (2024) which involved 202 respondents found similar results. In that study, a total of 101 (equivalent to about 47.6%) respondents reported a significant positive impact on their creativity skills from using ChatGPT, while 16 (approximately 7.5%) indicated that ChatGPT had no effect on their creativity. Similar positive impact of ChatGPT on students' creativity was observed in Urban et al. (2024).

On the other hand, Dwivedi et al. (2023) found that ChatGPT kills creativity since its solutions lack originality. This was supported by Matto (2024) & Hasanein & Sobaih (2023) who argued that the use of ChatGPT can diminish students' creativity. Further, in a study by Qawqzeh (2024) in which respondents who were on the view that ChatGPT does not enhance creativity exceeded those who were on the opposite view. Specifically, out of 515 respondents who participated in that study 181 (35.1%) believed that ChatGPT does not enhance creativity while 141 (27.4%) believed that it helps in generating creativity among students.

These contradicting findings entail that the effect of ChatGPT on creativity is not entirely positive or negative; it depends on the way in which students use it. Nevertheless, since it has potentials for bringing-in positive impacts, it should not be avoided in universities as a tool for enhancing creativity but, instead, students should be oriented to use it correctly for the desirable positive impacts on their creativity.

Problem-Solving

As it is in some other aspects of 21st century skills, there are diverse perspectives of scholars with regard to the impact of ChatGPT on students' problem-solving skills. A study by Urban et al. (2024) which investigated creative problem-solving performance in university students found that ChatGPT can provide support to students in the iterative development of their ideas, in which exploring those ideas in a greater detail, enables them to investigate the problem space in more depth, and thus develop more skills to solve the problem. Similarly, Bai et al. (2023) found that by automating routine tasks, ChatGPT can allow users to conserve mental energy, thereby facilitating higher-order cognitive functions such as problem-solving skills. Further, a study by Sart (2023) found that 86% of involved students indicated that ChatGPT helped them in comprehending the most complex concepts and in problem-solving. Other studies like Kılınç (2023) conclude also that ChatGPT develops problem-solving skills for university students.

On the other hand, however, there are scholars who believe that ChatGPT does not create problem-solving skills. Particularly, in their study, Krupp et al. (2024) analysed the impact of ChatGPT on problem-solving strategies of students and found that students who use ChatGPT perform significantly worse in terms of problem-solving compared to those not using it. This is in line with a study by Hasanein and Sobaih (2023) which claimed that the use of ChatGPT can decrease students' problem-solving abilities. Similarly, Khangkhan et al. (2024) revealed that while ChatGPT proves to be a valuable tool in enhancing problem-solving abilities among training staff, it provides an opposite reality when it is used by university students. Ferreira (2024) indicated that the reason might be students' overdependence on it which might limit their ability to solve problems on their own.

As it has been presented, one reason for the contradicting effects of ChatGPT with regard to problem-solving is determined by students' dependency on the tool. The more the dependency the less the ability for them to think critically and solve problems. This, again, calls for university educational stakeholders to find ways to help students to

balance the use of ChatGPT for their improved problem-solving skills.

Practical Implications

The study provides a comprehensive synthesis of existing studies with a focus of highlighting the effects of ChatGPT on 21st century skills of university students. While previous studies investigated a single skill at a time, this study focused on five skills (i.e. critical thinking, communication, collaboration, creativity, and problem-solving skills). This allowed comparative analysis of them in a single study. As a result, the study provides practical and impactful insights to educational stakeholders with regard to how and to what extent ChatGPT affects students' respective skills. For example, it has shown that, based on the magnitude of dependency, ChatGPT can bring positive or negative impacts on critical thinking, creativity and problem-solving skills. This means ChatGPT affects university students differently. While some benefit by improving their critical thinking, creativity, and problem-solving skills, others experience skill deterioration due to over-reliance on the tool.

On the other hand, ChatGPT brings more positive impacts on some aspects of communication skills and more negative impacts on collaboration skills in which existing studies show that the tool is generally bringing more isolations than working together among students. While previous studies indicate positive impacts of ChatGPT in terms of improving students' communication skills, the present study highlighted that ChatGPT should not be considered as a complete solution to the 21st century communication skills as such skills go beyond writing. Universities have been urged to consider other ways of improving students' effective listening and speaking skills as well as emotional intelligence.

Balancing the use of ChatGPT with creative autonomy requires a structured and deliberate frameworks rather than relying only on theoretical cautions. This demands, for instance, redesigning of assessments to foster academic honesty and integrity. Instructors should cultivate an environment where AI complements instead of replacing humans' positions. In that sense, students must be taught on how to use ChatGPT wisely rather than stopping them from using its.

Theoretical Implications

The study's findings support the constructivism theory. The study has shown that when students are engaged in learning activities (such as virtual interactions) through ChatGPT they build and improve their 21st-century skills. With regard to TRA, the study in some way concurs with the contextualized theory of reasoned action. Although it is true that the use of ChatGPT (i.e. behavioral intention) contributes to the building of 21st century skills (behaviors) as elaborated in the study, unlike TRA which claims that the stronger the behavioral intention, the more likely the behaviour happen, it is not necessarily true that the stronger the use of ChatGPT, the more the competence in the 21st century skills. Sometimes, this happens vice versa. That is, the more the use and dependency on ChatGPT the lesser the 21st century skills. This was specifically identified in collaboration skills, for example. It is not surprising therefore that studies like Duong et al. (2023) suggested moderated use of ChatGPT. Concerning ChatGPT's desirable

outcomes to student studies (i.e. attitudes) and pressure from peers and instructors (i.e. subjective norms), it was found that they influence the use of ChatGPT, which concurs with the theory of reasoned action.

Conclusion and Recommendations

The study has shed light on the effects of ChatGPT on 21st century skills of university students. By undertaking a thorough review on five skills (i.e., critical thinking, communication, collaboration, creativity, and problem-solving skills), the study unveiled considerable impact on pedagogical practices, engagement, and academic outcomes with regard to the use of ChatGPT amongst university students. The findings highlight that ChatGPT poses effects to students on each of the surveyed skills. However, the type and magnitude of effects depends on the type of skill. ChatGPT is found to bring more positive impacts to university students' communication skills. The tool enhances mainly written communications in which it was found that by interacting with it, students receive grammatical corrections which improves their writing skills. Other aspects of communication skills such as listening and speaking skills are not well addressed by ChatGPT. It was found further that ChatGPT affects collaboration skills in which the tool brings more isolations to students which reduces their ability to collaborate. While those were the case, this study found that ChatGPT can bring either positive or negative impacts on critical thinking, creativity and problem-solving skills. The effects depend mainly on the magnitude of students' dependency on it. Those that depend more on it are likely to be more negatively affected. For instance, it was found that the more the students depend on ChatGPT, the less the ability for them to think critically and solve problems.

Since ChatGPT has potential to bring-in positive impacts, the study calls for universities to embrace it instead of avoiding it. However, universities should endeavour to reduce students' over-reliance on it by implementing respective guidelines as well as AI literacy programs to ensure ChatGPT is used productively. In addition, universities should cultivate a culture of analytical reasoning by requiring students to deeply analyse information provided by ChatGPT and embed their own perspectives in the answers it provides. There is also a need to incorporate more hand-on activities and assignments that require not only deep thinking but also collaborative works by students. Further, while ChatGPT presents an opportunity to improve communication skills to university students, there must be further complementary initiatives to improve students' effective listening and speaking skills as well as emotional intelligence. The future research directions would be to undertake the study using primary data to see if same results will be obtained. It is important also to include other 21st century skills as some of them were left out in this study.

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RESEARCH ARTICLE **Open Access**

Designing a Human Resource Productivity Model based on the Material Benefits of Personnel in the Iraqi Civil Defense Corps

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Abstract
The material interests of personnel significantly affect the productivity and quality of services provided. Understanding these interests is very important for organizations that aim to increase employee motivation and performance. The aim of this research is to design a human resource productivity model based on the material interests of personnel. The research is exploratory-applied in terms of its purpose and survey-correlation in terms of its method. The research was conducted in a qualitative-quantitative manner. The statistical population in the qualitative part is university professors and fire department managers in Iraq. The statistical population in the quantitative part consists of all fire department employees in Iraq, which is considered to be an unlimited number, so the sample size is 384 people based on the Cochran formula. The research tool is a researcher-made questionnaire. Data analysis in the qualitative part is the theme method and in the quantitative part is structural equations in the PLS software. The results of the study indicate that in the qualitative part, 5 main dimensions have been extracted, which include fair and competitive salaries and wages, bonuses and fringe benefits, job security and financial stability, financial growth opportunities through performance, and support for work-life balance with economic benefits. In the quantitative part, the overall fit of the research model based on the GOF formula was obtained as 0.65, which indicates a strong fit. The first and second order factor loadings have been confirmed with 99% confidence.

Keywords: Human Resources, Resource Efficiency, Material Benefits, Iraqi Civil Defense Corps

Introduction

Due to several factors, few societies around the world have experienced an external, unpredictable, social and dynamic environment. Human resource departments of various organizations are affected by the external environment. These factors show both a danger and an opportunity for the human resources sector (Rizal et al., 2017). As the main responsibility of the human resources sector is to offer efficient and effective resources, strategies should be implemented to decrease the issues which can be effective on human resource policies in organizations (Al Doghan et al., 2023). Humans are social animals that interact with others while living in a society. People cannot live in seclusion. Hence, decisions of one person are affected by the society. Researchers believe that focusing on human

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behavior and the effective factors on it is necessary (Osadzy, 2017). Employees' culture of hard work reinforces the employer-employee relationship. When an organization hires a person, a new relationship is formed between the organization and the employee (White et al., 2020). As employees and employers develop close working relationships, their relationships grow. Failure or success of the organization should manage this relationship. Business owners have to diagnose the importance of human resources for the organization (Ansah et al., 2018). Employee relationship management is to create alignment among all beneficiaries to enhance employee participation and organizational efficiency. It is possible to reduce attrition rate of the organization over time and increase its efficiency. Economic factor and material interests are effective on this flow (Rahman & Taniya, 2017). Given the above-mentioned issues, incentives, wage, and base pay are offered to increase employee motivation. Offering incentives can be in the form of financial incentives, i.e. money, bonus, commission, compensation of old age benefits, overtime, and social security. Moreover, non-financial incentives as annual leave, granting certification and acknowledgement can be offered too (Zebua et al., 2023). Motivation has a major role in employee performance. Although organizations are interested in maintaining employee motivation in the workplace but a perfect picture of an employee motivation does not always exist. Researchers agree that money (including employees' wage) is considerably effective on employee performance and productivity (Uka et al., 2021). Inflation is harmful for employees because it decreases their purchasing power. On the other hand, they are faced with problems in their savings. Inflation creates ambiguity in a country and makes planning at micro and macro levels difficult (Jayaweera et al., 2022). Among other macro-economic factors, inflation and unemployment have the highest effect on employees' decision-making. They experience *psychological distress*, wastage of human resources, increased crime rate, and economic deprivation (Akinsomi et al., 2018). The above-mentioned factors related to training, wage and other benefits are effective on strategic relations of employees. Thus, these social and economic factors affect job satisfaction and as a result cause to decrease or increase employee productivity (Jayaweera et al., 2021).

This study explores employee productivity in the Iraqi Civil Defense Corps based on material interests. One of the effective tools for realization of material interests and enhancement of occupational activity of employees in the Iraqi Civil Defense Corps is financial incentives. A proper system makes use of financial incentives to achieve production indicators and human resource productivity. This is obtained through implementing tariff rates which consider complexity, working conditions and importance of its use, various forms of wages and incentive systems, payments and extra premiums and so on. Thus, organizing rewards based on the principle of material interests of each employee in individual and collective outcomes is one of the effective tools to enhance occupational activity of employees in a firm that finally increases efficiency. Growth of labor productivity due to increased activity and providing the conditions to address the material component of personnel including material incentives and reward lead to acceptable results in an

organization. All these points are reflected in the structural and logical plan to improve organizing material motivations and their effect on the growth of labor productivity of the Iraqi Civil Defense Corps through realization of material interests of workers. The process of improving material motivations begins with identification of the existing system of motivations and reward, analysis of employee satisfaction with its elements, studying the job market, and investigating financial capabilities of the firm. Exploring the structure of work motivation of personnel to improve the material incentives and reward system is necessary. In addition, analyzing employees' performance evaluation system that is performed in the framework of employees' material interests helps identify deficiencies in the reward system and regulate performance indexes by taking into account the purposes of the organization and productivity.Given that employees feel that financial benefits are not distributed fairly or are insufficient, they may lose their motivation to work. This can become one of the most fundamental challenges in increasing productivity. Also, cultural and social issues specific to Iraq may lead to inconsistencies in human resource policies and material benefits. These factors can include economic pressures, social instability, and cultural changes. It can be said that if material benefits are provided in a way that does not encourage the development of skills and improvement of capabilities, employees may remain in work positions without increasing their productivity. Also, there is rarely sufficient and reliable research and studies in this field that can properly analyze the relationship between material benefits and productivity rates in the Iraqi Civil Defense Corps. Considering the above, this study aims to fill the research gap. In this regard, probable growth of labor productivity due to reinforcement of material interests of workers in work results and job activity and considering it in employees' efficiency outcome is important. It is important to determine the effect of growth of labor activity and reinforcement of material motivations on changing of labor productivity in the Iraqi Civil Defense Corps. In this way, they can develop actions to improve the material incentives and reward system. To this end, new policies regarding material incentives and reward of personnel should be formulated and developed based on the strategic purposes of the organization and tasks in the field of employee motivation and incentives. And finally, a mechanism should be provided to improve the material incentives system of the personnel in the Iraqi Civil Defense Corps. Thus, the below question is proposed:

How is the design of human resource productivity model based on material interests of the personnel in the Iraqi Civil Defense Corps?

Research Literature

Material interests of personnel

Material interests like wage and reward are essential to motivate the transportation personnel and are directly related to increased labor productivity (Irina et al., 2022). There is a significant relationship between material motivations and increased productivity and quantitative analyses confirm that timely motivations are led to better performance of employees. Lack of a well-defined motivational system can decrease employee competitiveness and motivation and has a negative effect on total

productivity. While material incentives are effective, paying attention to non-financial incentives like career recognition and development is necessary which can enhance employee motivation and productivity considerably (Irina et al., 2022). Material support of the public service personnel including allowances and rewards plays an important role in their job performance and satisfaction (Komiljon et al., 2022). Public compulsory social security acts as a primary material guaranty for people with family responsibilities and supports them during temporary disabilities and other events. Financing resources include contributions of the employer and the insured people that ensures the benefits are accessible if necessary (Сохань, 2020).

Human resource productivity of firefighters

The relationship between employee productivity and performance is necessary for success of the organization. Productivity shows how effectively and efficiently employees perform their tasks while employee performance involves more extensive aspects like job satisfaction and motivation. This relationship is complex and affected by factors like work environment and *manager-employee relationship*. Continuous research has highlighted a positive and significant relationship between employee productivity and performance (Arif, 2023). Hence, the relationship between employee productivity and performance is positive which is affected by factors such as work environment, job satisfaction, employee-manager relations and is closely associated with total performance of employees (Mardas et al., 2024). Moreover, work discipline is effective on employee productivity. For instance, lack of discipline leads to employee absenteeism without any explanation that is effective on productivity (Kurniawan et al., 2024).

Fire safety equipment

According to Bambang, firefighters are champions who are working to protect the society and property against dangers of fire. Via this statement, firefighters have a very dangerous job and need optimal protection to perform their tasks effectively and securely. Personal protective equipment (PPE) includes fire-resistant clothing, helmet, glove, heat-resistant shoes, and respiratory equipment. There are several factors to protect firefighters against dangers of heat, smoke and dangerous chemicals that may be involved in firefighting activities (Sharp et al., 2024).

According to Ishengoma (2024), personal protective equipment has the capability to protect a person at work and separates the worker's body from existing dangers at the work environment. Helmet, belt and harnesses, fire boots, protective shoes, masks, ear muffs, goggles, gloves, face shields, life jackets, anti-virus masks and heat-resistant protective clothing are the personal protective equipment (Nazara et al., 2024).

Physical health threat of firefighters

Firefighting has been recognized as an unpredictable, dangerous, and difficult task. Intensive physical nature of job, psychological stress and harmful factors of lifestyle increase the risk of cardiovascular diseases and premature mortality of firefighters because of sudden cardiac events (SCEs) (Fahy et al., 2021). Several authors have identified pathogenic mechanisms of sudden cardiac events which may occur

during suppression activities (Santos et al., 2023).

Research Background

Madzík et al. (2025). Conducted a study titled "The impact of motivation and management system on individual and organizational performance" This research introduces a new approach to exploring the relationship between motivational factors, management systems and performance at both individual and organizational levels. Unlike previous studies that focused on isolated performance components, our research presents a comprehensive model integrating these factors into a unified framework. This model offers deeper insights into how the combination of internal motivations and management systems impacts performance in various contexts. The research fills a gap in the literature on the interactions between these key components and provides new empirical evidence on their influence in achieving performance goals. Chi et al. (2023) conducted a study titled "How Financial and Non-Financial Rewards Moderate the Relationships between Transformational Leadership, Job Satisfaction, and Job Performance." The results show that transformational leadership significantly affects job satisfaction, which in turn is strongly related to job performance. Uka et al. (2021) conducted a study titled "Motivation as an Indicator of Performance and Productivity from the Employee Perspective". The results showed that the level of satisfaction and motivation at work was moderate and there was a significant correlation between motivation and company success. In addition, the data indicated that most participants were satisfied with financial allowances, but wished for higher wages and better working conditions. Therefore, higher salaries, additional bonuses, and promotion of their role in work or recognition and appreciation seem to be very important motivational factors for employees. Ariani et al. (2024) conducted a study titled "With or without job satisfaction? The role of job satisfaction in the relationship between training and rewards on employee productivity". Statistical analyses show that training and rewards have a direct impact on employee job satisfaction and productivity. Companies should prioritize job satisfaction with more comprehensive proportions. Ichdan et al. (2024) analyzed employee performance through productivity: The role of kaizen culture, motivation and work discipline in the manufacturing industry. They emphasized the importance of these elements in enhanced organizational performance and proposed practical suggestions for companies that aim to increase employee productivity and participation.

Diawati et al. (2023) explored the role of information technology in improving the efficiency and productivity of human resources in the workplace and concluded that in the ever-changing digital age, the importance of information technology in increasing of human resources effectiveness and output in the workplace is highly important. Information technology facilitates automation of daily tasks, increases cooperation, provides suitable access to the information, makes effective education possible, supports smart data analysis, enhances efficient performance management, provides the possibility for job flexibility, and guarantees information security.

Zebu et al. (2023) investigated the effect of human resources quality, performance

evaluation and incentives on employee productivity at Raharja High School. They concluded that human resources quality with path coefficient equal to 0.145 has a positive effect on employee productivity; human resources quality with path coefficient equal to 0.121 has a positive effect on motivations; incentives with path coefficient equal to 0.784 have a positive effect on productivity while performance evaluation with path coefficient equal to -0.103 does not have a positive effect on employee productivity. It can be stated that all research hypotheses except one hypothesis have positive effect. According to results of data analysis, human resources quality is directly effective on employee productivity at Raharja High School. Thus, the hypothesis that states human resources quality has a direct effect on employee productivity is accepted.

In a study titled "patent productivity: strategic human resources and the attention-based view" Greer et al. (2023) explored rhetoric of strategic human resources management by senior management team, presence of a human resources manager, and weakness of human resources. This study reveals that innovative rhetoric of strategic human resources management can be helpful in patent productivity while weakness of human resources decreases patent productivity. With a deeper look at this concept, it can be found that time delays adjust the effect of rhetoric of innovation and administrative effect of human resources on patent productivity.

Tarigan et al. (2022) explored total reward system, job satisfaction and employee productivity on company financial performance: evidence from Indonesian Generation Z workers. They concluded that adopting a reward system has a positive effect on the results. However, the interesting reality about this finding is that the Generation Z cannot be easily persuaded just by monetary incentives. Their preference has shifted from monetary concerns to personal ability. Empirical results show that the reward system acts as a tool to encourage employees and enhance productivity. Thus, firms have to utilize reward system methods to increase job satisfaction and productivity as well as maintain the relationship with beneficiaries. Also, management should pay attention to maintain good employee productivity to improve financial performance of the company through supervision of operations of the company and also ensuring that the beneficiaries ' interests are realized.

Bogatyreva et al. (2022) examined the influence of material interests of transportation personnel on the growth of labor productivity. They proposed a structural and logical plan to improve organization of material motivations and their effect on the growth of labor productivity through realization of material interests of transportation workers.

Methodology

The present study aimed to design a human resource productivity model based on the material benefits of personnel in the Iraqi Civil Defense Corps. The research is exploratory-applied in terms of its purpose and survey-explanatory in terms of its method. The research was conducted in a qualitative-quantitative manner. The statistical population in the qualitative section included university professors and heads and deputies in the Iraqi Civil Defense Corps. The statistical population in the quantitative section included all employees

of the Iraqi Civil Defense Corps, whose number was considered unlimited, therefore the sample size based on the Cochran formula was equal to 384 people. The research tool was a researcher-made questionnaire. The research tool is a researcher-made questionnaire. Data analysis in the qualitative part is the thematic analysis and in the quantitative part is structural equations in the PLS software. Validity of the questionnaire has been confirmed by a group of management professors. To test reliability of the questionnaire, Cronbach's alpha was used where all components were reliable with the Cronbach's alpha greater than 0.7.

Findings

Demographic findings

Table 1 shows findings on demographic characteristics of participants that include age average, average work experience, and education.

Table 1.

Demographic characteristics of the experts under study

Group	Number	Age average	Average work experience	Education	
				MA	PhD
Fire department managers	5	49.33	19.25	20%	80%
University experts	5	56.66	22.50	-	100%

Having explored age average of the experts under study, it was determined that university professors and experts with an age average of 56.66 years old have the highest age group and fire department managers with an age average of 49.33 have the lowest age group. Exploring work experience showed that university professors and experts with 22.50 years of work experience have the highest experience and directors of the Ministry of Higher Education and Scientific Research with 19.25 years have lower work experience than the university professors and experts. Among the participants, 9 had PhD and 1 had MA degree.

Extracted secondary codes

First, researchers read the text carefully and then they extract secondary codes. The secondary codes obtained from primary codes and re-extracted from interviews conducted in this study are reported in Table 2.

Table 2.

Dimensions and extracted secondary codes

Row	Purpose	Research dimensions	Extracted secondary codes
1		Fair and competitive salaries and wages	Proportion of wage with specialty and experience
2			Transparency in payment system
3			Competitiveness of paid wage
4			Timely and regular payment of salaries
5			Annual raise and adaptation with inflation
6		Bonuses and fringe benefits	Offering financial facilities
7			Developing performance reward
8			Allocation of employees' share of research revenues

Row	Purpose	Research dimensions	Extracted secondary codes
9			Payment of allowances
10	Human resource productivity based on material interests of personnel		Job-related non-financial benefits
11		Job security and financial stability	Type of fair employment contract
12			Sustainable financing
13			Observing labor laws
14			Offering various insurances
15			Guaranteeing lack of human resource adjustment
16		Financial growth opportunities through performance	Transparent performance evaluation system
17			Productivity-based payments
18			Earning money from research projects
19			Job promotion with pay raise
20			Offering financial opportunities for innovation
21		Support for work-life balance with economic benefits	Family allowances
22			Paid leave
23			Reduction of financial pressure during retirement
24			Financial facilities for recreation and welfare
25			Flexible working hours

Final model

Final model of the research is shown in Figure 2. Five main dimensions have been obtained including fair and competitive salaries and wages, bonuses and fringe benefits, job security and financial stability, financial growth opportunities through performance, and support for work-life balance with economic benefits. Aldo, 128 primary codes were extracted from 10 interviews among which 25 secondary codes were obtained.

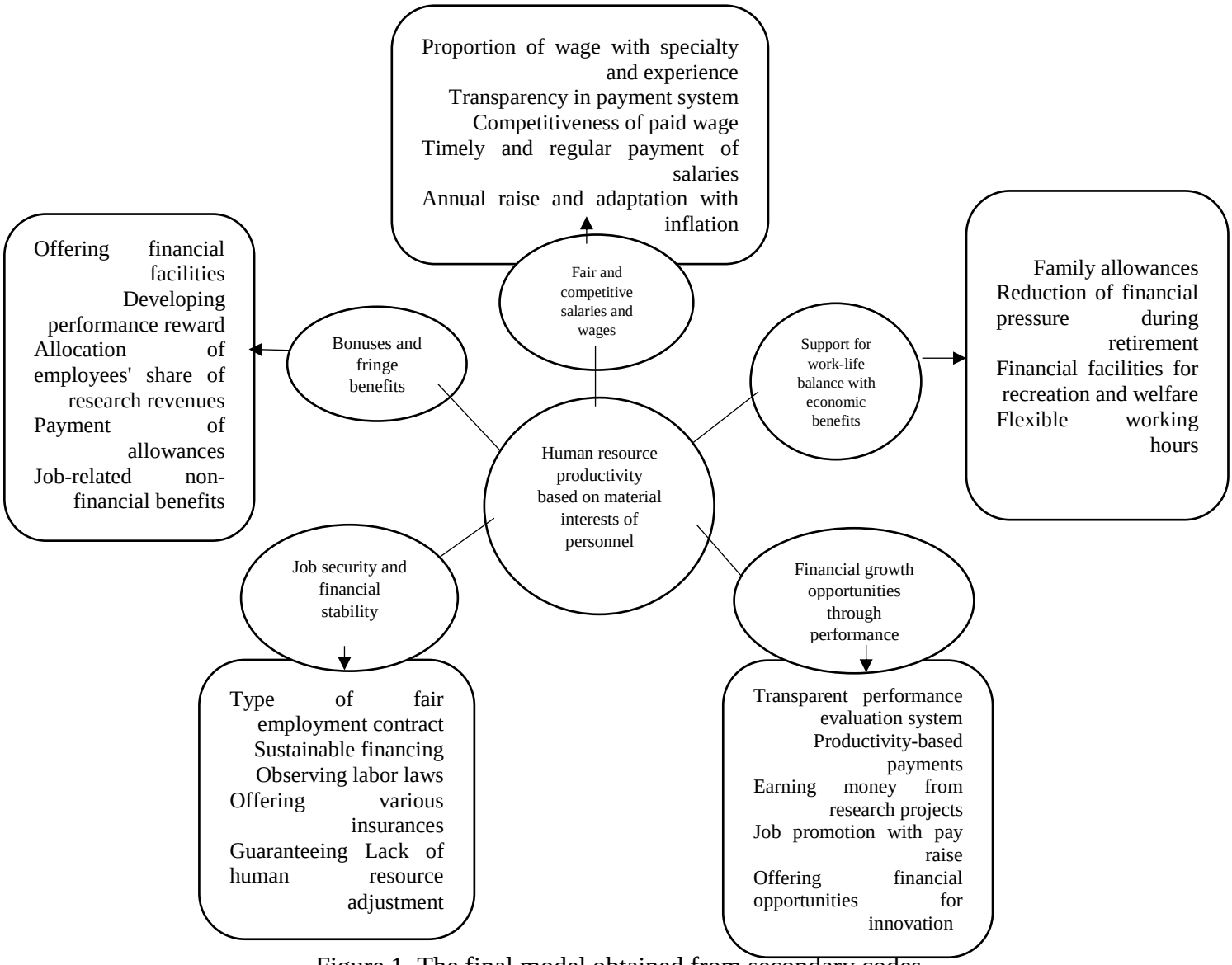

Figure 1. The final model obtained from secondary codes

Findings

Demographic statistics

Table 3 displays demographic statistics of the statistical sample including gender, age, education, and work experience.

Table 3.

Descriptive statistics

Gender	**Frequency**	**Frequency percentage**	**Cumulative frequency percentage**
Male	338	88.02	88.02
Female	46	11.98	100
Sum	384	100	
Age	Frequency	Percentage	Cumulative frequency percentage
20-30	98	25.52	25.52
31-40	161	41.93	67.45
41-50	86	22.4	89.84

Gender	Frequency	Frequency percentage	Cumulative frequency percentage
51 and higher	39	10.16	100
Total	384	100	
Education	Frequency	Percentage	Cumulative frequency percentage
BA	214	55.73	55.73
MA	142	36.98	92.71
PhD	28	7.29	100
Total	384	100	
Work experience	Frequency	Percentage	Cumulative frequency percentage
5 years and lower	89	23.18	23.18
6-10 years	119	30.99	54.17
10-11 years	92	23.96	78.13
More than 15 years	84	21.88	100
Total	384		

Source: Research data

Research components and items

Research components and items and the symbols are represented in Table 4.

Table 4.

Research components and items

Row	Purpose	Dimensions	Symbol	Item
1		Fair and competitive	q1	Proportion of wage with specialty and experience
2		salaries and wages	q2	Transparency in payment system
3			q3	Competitiveness of paid wage
4			q4	Timely and regular payment of salaries
5			q5	Annual raise and adaptation with inflation
6		Bonuses and	q6	Offering financial facilities
7		fringe benefits	q7	Developing performance reward
8	Human resource productivity based on		q8	Allocation of employees' share of research revenues
9	material interests of		q9	Payment of allowances
10	personnel		q10	Job-related non-financial benefits
11		Job security and	q11	Type of fair employment contract
12		financial stability	q12	Sustainable financing
13			q13	Observing labor laws
14			q14	Offering various insurances
15			q15	Guaranteeing lack of human resource adjustment
16		Financial growth opportunities	q16	Transparent performance evaluation system
17		through	q17	Productivity-based payments
18		performance	q18	Earning money from research projects
19			q19	Job promotion with pay raise
20			q20	Offering financial opportunities for innovation
21		Support for work-	q21	Family allowances
22		life balance with	q22	Paid leave
23		economic benefits	q23	Reduction of financial pressure during retirement
24			q24	Financial facilities for recreation and welfare
25			q25	Flexible working hours

Exploring relations among variables

After exploring model fit of the measurement models, structural model and general model according to the algorithm of data analysis in PLS method, the researcher can explore and test relations among the variables. In this section, standardized coefficients of paths related to the hypotheses and t-values are examined. To confirm or reject the hypotheses, t-value must be greater than 1.96 or less than -1.96. Values between the two figures indicate lack of significant difference of the calculated amount for regression weights equal to zero at the level 95%. Figure 2 shows output of factor loading and Figure 3 shows t-values related to relations among the variables.

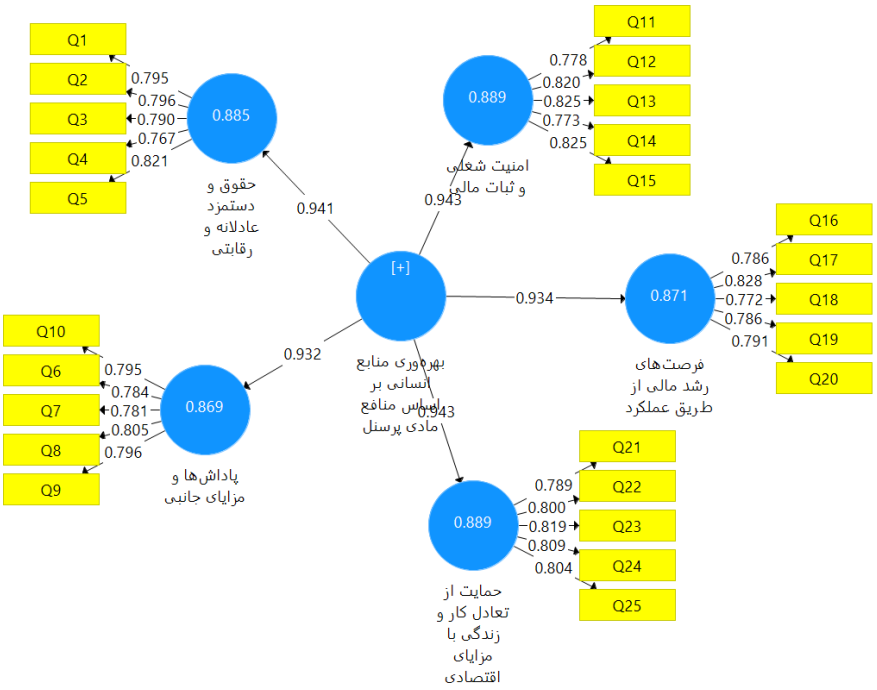

Figure 2. Research model and standardized coefficients

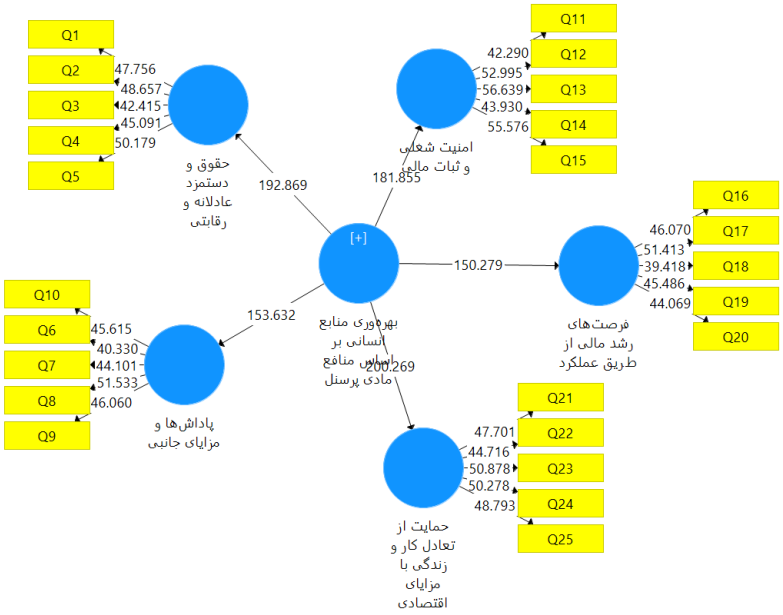

Figure 3. Research model and t-values

Research Constructs

Table 5 describes the research constructs.

Table 5.

Description of research constructs

Component	Reliability		Convergent validity		Results of convergent validity
	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)	
Job security and financial stability	0.863	0.864	0.902	0.647	It is confirmed.
Human resource productivity based on material interests of personnel	0.967	0.967	0.97	0.56	It is confirmed.
Fair and competitive salaries and wages	0.853	0.853	0.895	0.63	It is confirmed.
Support for work-life balance with economic benefits	0.864	0.864	0.902	0.647	It is confirmed.
Financial growth opportunities through performance	0.852	0.852	0.894	0.628	It is confirmed.
Bonuses and fringe benefits	0.852	0.852	0.894	0.628	It is confirmed.

AVE>5/0 , CR>7/0 , rho_A>7/0 , Alpha>7/0

Considering Table 3, Cronbach's alpha and composite reliability are greater than 0.07 that show reliability of the research data. It is observed that the Average Variance Extracted (AVE) is always greater than 0.5 and composite reliability has also been obtained greater than 0.7 in all cases which is greater than the Average Variance Extracted (AVE). Thus, convergent validity is confirmed too.

Overall fit of the research model

To examine the overall fit of the research model that controls both the measurement model and structural model, GoF formula is used. It is calculated via formula 1.

$$GOF = \sqrt{\overline{Communalities} \times \overline{R^2}} \quad (1)$$

Table 6 shows average communality values and average R Squares that GoF is equal to 0.67 which shows a strong fit.

Table 6.

Average communality values and R Squares

	R Square	Communality	avg-communality	avg-R
Job security and financial stability	0.889	0.518		
Human resource productivity based on material interests of personnel	-	0.495		
Fair and competitive salaries and wages	0.885	0.467		
Support for work-life balance with economic benefits	0.889	0.421	0.487	0.881
Financial growth opportunities through performance	0.871	0.543		
Bonuses and fringe benefits	0.869	0.476		

Relations among the research dimensions and components

Given Figures 2 and 3, a summary of the results is represented in Table 7.

Table 7.

Result of relations among the research dimensions and components

	Factor loading	**t-value**	**P values**	**Status**
Human resource productivity based on material interests of personnel-> Job security and financial stability	0.943	181.855	0	It is confirmed.
Human resource productivity based on material interests of personnel-> Fair and competitive salaries and wages	0.941	192.869	0	It is confirmed.
Human resource productivity based on material interests of personnel-> Support for work-life balance with economic benefits	0.943	200.269	0	It is confirmed.
Human resource productivity based on material interests of personnel-> Financial growth opportunities through performance	0.943	150.279	0	It is confirmed.
Human resource productivity based on material interests of personnel-> Bonuses and fringe benefits	0.932	153.632	0	It is confirmed.

Given Table 7:

- In the relationship between human resource productivity based on material interests of personnel with job security and financial stability, a significant relationship has been obtained that is equal to 181.855 (t-value>1.96). Therefore, this relationship is significant. Second order factor loading has been computed equal to 0.943.
- In the relationship between human resource productivity based on material interests of personnel with fair and competitive salaries and wages, a significant relationship has been obtained that is equal to 192.869 (t-value>1.96). Therefore, this relationship is significant. Second order factor loading has been computed equal to 0.941.
- In the relationship between human resource productivity based on material interests of personnel with support for work-life balance with economic benefits, a significant relationship has been obtained that is equal to 200.269 (t-value>1.96). Therefore, this relationship is significant. Second order factor loading has been computed equal to 0.943.
- In the relationship between human resource productivity based on material interests of personnel with financial growth opportunities through performance, a significant relationship has been obtained that is equal to 150.279 (t-value>1.96). Therefore, this relationship is significant. Second order factor loading has been computed equal to 0.943.
- In the relationship between human resource productivity based on material interests of personnel with bonuses and fringe benefits, a significant relationship

has been obtained that is equal to 153.632 (t-value>1.96). Therefore, this relationship is significant. Second order factor loading has been computed equal to 0.943.

Significance of all relations has been obtained greater than 1.96 (t-value>1.96). Thus, all relations are significant and confirmed.

Discussion and Conclusion

This study was conducted to design a human resource productivity model based on the material benefits of employees in the Iraqi Civil Defense Corps. Therefore, the general research question is: How to design a human resource productivity model based on the material benefits of employees in the Iraqi Civil Defense Corps? The human resource productivity model based on the material benefits of employees in the Iraqi Civil Defense Corps includes 5 dimensions, fair and competitive salaries and wages, bonuses and fringe benefits, job security and financial stability, financial growth opportunities through performance, and support for work-life balance with economic benefits. Also, in the structural equation modeling section, the validity of the model of the relationships of dimensions and components has been confirmed. The relationship between human resource productivity based on the material benefits of personnel and job security and financial stability is significant. In explaining this result, it can be said that when employees feel job security and are financially secure, they often continue to work with more motivation. This security frees their minds from financial and job worries and they can focus more on performing their duties. When employees are worried about losing their jobs or financial instability, they are likely to not focus enough on their work. This can lead to a decline in work quality and reduced productivity. Employees who feel secure in their organization tend to be more committed to their organization and, as a result, are more likely to conform to the organization's values and goals. This commitment can lead to improved overall organizational performance. Organizations that care about providing financial and job security to their employees tend to provide a positive work environment. This research is consistent with the study by Chi et al. (2023) titled "How Financial and Non-Financial Rewards Moderate the Relationships between Transformational Leadership, Job Satisfaction, and Job Performance." Chi et al. (2023) found that financial rewards have a negative moderating effect on the relationship between transformational leadership and job performance. These findings suggest that managers may benefit from combining transformational leadership with financial rewards to motivate employees and improve job performance. Human resource productivity based on material benefits of personnel has a significant relationship with fair and competitive salaries and wages. In explaining this result, it can be said that competitive salaries and wages act as a motivating factor. When employees feel that they are being paid appropriately according to their skills and experience, they are more motivated to work harder and better. This can lead to increased productivity. Organizations that offer fair salaries and benefits may help attract and retain talented and skilled employees. Talented employees are more likely to stay in an environment with competitive wages, which leads to strengthening the organization's capabilities and increasing its

productivity. If salaries and wages are low or unfair, employees may feel dissatisfied and consider changing jobs. This dissatisfaction can reduce motivation and productivity. In contrast, fair wages can enhance job satisfaction and increase motivation. Paying fair and competitive salaries and wages helps to form a positive organizational culture. Competitive wages give employees the feeling that the organization is growing and successful. This confidence can lead to strengthening work processes, increasing innovation, and ultimately improving productivity. This research is in line with the study by Oka et al. (2021) entitled “Motivation as an indicator of performance and productivity from the perspective of employees”. The results showed that the level of satisfaction and motivation at work is moderate and there is a significant correlation between motivation and company success. Human resource productivity based on the material benefits of personnel has a significant relationship with economic benefits by supporting work-life balance. In explaining this result, it can be said that supporting work-life balance can reduce stress and fatigue. When employees feel that the company values their personal and family life and provides appropriate economic benefits for this purpose, they will be more motivated and able to focus on work. This usually leads to increased productivity. A good work-life balance leads to increased job satisfaction. When employees can have enough time for family, recreation, and personal activities, they feel happier and more fulfilled at work, which in turn leads to increased productivity. Organizations that focus on work-life balance typically have lower absenteeism and employee turnover. This stability can help improve productivity because the organization can focus on developing and improving employee skills and reduce the costs of moving and training new employees. Creating work-life balance gives employees the opportunity to rest and refresh their minds. This rejuvenation can increase creativity and innovation at work, which in turn helps improve organizational productivity. Organizations that focus on and support work-life balance create a more positive culture. These benefits make employees feel that they are receiving financial and emotional support from the organization, which can lead to increased commitment and productivity. This result is consistent with Sekura's (2024) study entitled "Employee motivation as a factor for improving the efficiency of the management system."This study is dedicated to employee motivation to increase the efficiency of the organization's management systems. Organizational and economic relations arise from the process of motivating employees to increase the efficiency of the management system. Human resource productivity based on personnel material benefits has a significant relationship with financial growth opportunities through performance. In explaining this research, it can be said that when employees have clear opportunities to increase their income through better performance, they usually show more motivation to try and improve their performance. This stimulation can be in the form of financial rewards, salary increases, or opportunities for promotion. Providing financial growth opportunities usually creates higher standards of quality and productivity in employees. Employees are driven to challenge themselves and strive to be the best at their work in order to benefit from financial benefits. Organizations that

give their employees financial opportunities based on performance help strengthen their commitment and loyalty. Employees feel that their efforts are appreciated and lead to a specific reward. This commitment can help improve productivity, as employees are more likely to stay in their workplace and contribute to the growth of the organization. Organizations that provide attractive financial opportunities for their employees are usually able to attract top talent. These talents can play a key role in increasing the productivity and innovation of the organization. Financial growth opportunities are usually associated with training and personal development. Organizations provide their employees with the necessary training so that they can prepare for promotion in their jobs. This personal development is not only beneficial to the employees themselves, but also increases the productivity of the entire organization. Organizations that provide growth opportunities and appropriate financial rewards help create a healthy competitive environment among employees. This competitive environment can lead to improved and increased group performance and productivity. Human resource productivity based on the material benefits of personnel has a significant relationship with bonuses and fringe benefits. Bonuses and fringe benefits such as scholarships, health insurance, paid vacations, and work from home can act as incentives that encourage employees to work harder and perform better. This motivation can take the form of increased work quality and greater productivity. When employees receive reasonable fringe benefits, such as health plans, financial benefits, or flexible working options, they will feel more satisfied with their jobs. This satisfaction will lead to increased commitment and motivation to work, which in turn increases productivity. Providing appropriate fringe benefits can lead to reduced absenteeism and employee turnover. Employees who feel supported and cared for by the organization are less likely to consider changing jobs, and this stability can contribute to higher organizational productivity. Bonuses and fringe benefits improve the quality of the employee work experience. A positive workplace experience can increase motivation, engagement, and collaboration in teams, which in turn affects overall productivity. The results of this study are consistent with the results of the research by Ariani et al. (2024) entitled “With or without job satisfaction? The role of job satisfaction in the relationship between training and rewards on employee productivity.” Statistical analyses by Ariani et al. (2024) show that training and rewards have a direct effect on employee job satisfaction and productivity.

In this regard, the below suggestions are presented:

1) Compensation of competitive services: it is necessary to ensure that the personnel wage and benefits compete with the labor market. This can create more motivation for employees.
2) Performance rewards: implementing reward systems based on performance can create more motivation for employees to do their tasks with the best quality.
3) Additional benefits: offering additional benefits like medical insurances, retirement plans, and related compensations can make employees more committed to the organization.

This study proposes some suggestions for future studies: 1) predictive modeling of employee performance based on financial interests: creating models to predict employee performance given financial and non-financial interests; 2) the effect of financial motivational programs on new generation of employees: exploring how new generations (like Generation Z) respond to various financial options and which tendencies they have.

There are no conflicts of interest.

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RESEARCH ARTICLE **Open Access**

Designing a Model for Human Resources Architecture with an Intelligent Approach in Tax Administration in Southeastern Provinces of Iran

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Abstract
This study was conducted with the aim of designing the architectural model of human resources of Tax Administration in Southeastern Provinces of Iran with the intelligent approach. This study was of a mixed type and the statistical population in the qualitative part was 20 experts of Tax Administration managers in the southeastern provinces of Iran (TASEPI), namely Sistan and Baluchistan, Kerman, Hormozgan and South Khorasan. 264 people were selected using G*Power. Sampling of the qualitative part was purposeful and the quantitative part was random cluster sampling. The data collection tool was a researcher-made questionnaire containing 77 items that included six dimensions of intelligent human resources architecture and six dimensions of intelligentization. The software used was Smart-PLS and SPSS-16. The results showed that the dimensions of human resource architecture were effective in the way of intelligentization as follows: intelligent human resource system (0.965), intelligent human resource management (0.960), intelligent organizational learning (0.955), and intelligent organizational architecture strategy (0.953). Technology-oriented (0.945) and smart knowledge management (0.451). The dimensions of intelligentization are also from the dimension of intelligentizing human resources (0.974), intelligent participation of employees (0.965), human resource maintenance activities (0.962), forming a talent fund (0.949), advanced functional activities (0.927) and the dimension of creating new roles of human resources (0.895). Managers should try to draw and compile the horizon of intelligent organizational architecture and in line with the implementation policies of intelligentization and plan to acquire new technologies in the field of artificial intelligence and use it.

Keywords: *Intelligentization of human resources, Intelligentization, Tax Administration in Southeastern Provinces of Iran (TASEPI), Human resources intelligent management*

Introduction

Like any other scientific subject, human resource management faces new approaches resulting from the business environment requirements. Organizational architecture is a comprehensive plan that acts as a coordinating force between different dimensions of the organization (Coupe, 2019). Technological advances and innovations for humans increasingly bring complex outcomes. The role of machines is changing from beneficial tools for production or use to playing a vital role in various areas of human organizational and economic life (Ardakani, et al., 2019). Human resource architecture includes a set of tasks and human resource management systems that create certain behaviors in employees given the

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differences in their characteristics (Spencer et al., 2012). These digital technologies cause fundamental changes in the work environment of human resource managers. Scientists have focused more on the impacts of certain technologies on organizations and their managers (Henfridsson et al., 2014). Rapid technological changes, especially in the digital age, and lack of coordination with the level of knowledge and competence may cause a large gap between the actual competitive levels required by human beings. Artificial intelligence is mostly utilized in recruitment, training, employee engagement, and employee retention. It helps to reduce costs, save time, and complete human resource tasks more accurately (Tohidenjad & Moghadasi, 2021). Based on the studies by Alexander Mann, 96% of the surveyed human resource experts believe that artificial intelligence technology can improve talent acquisition (Nair, 2017).

Previous studies have indicated how artificial intelligence affects specific human resource tasks in the organization. Intelligent sensing mechanisms have been useful in evaluating employee productivity and identifying knowledge hiding (Saxena & Kumar, 2020). The focus of existing studies on the role of artificial intelligence in human resource management has been on its application at the functional level. This study presents a human resources architecture model with the intelligentization approach in TASEPI. Human resource architecture is a new field in human resource management literature. It aims to highlight the role of hiring key employees in realizing the organization's missions and strategies. Given the impact of the intelligentization of the organization on the job description of the employees of TASEPI and the need for new knowledge-oriented and expertise-oriented employees in these organizations, the researcher of this study aims to develop a model for the human resource architecture using intelligentization approach in TASEPI to identify the architectural model of human resources with the intelligentization approach in TASEPI.

Methods

Research setting and population

The present study was a mixed (qualitative-quantitative) research. It presented a model qualitatively using a content analysis method. The model was tested quantitatively with the confirmatory factor analysis method in Smart Pls software.

Data collection method

The first (qualitative) stage: In the first stage, this study was interpretive regarding paradigm, inductive regarding its approach, and qualitative regarding its method. It is also single cross-sectional regarding time horizon. It also uses library sources and interviews to collect data. The number of Delphi working groups in this study was 20 people with sufficient knowledge and expertise on the subject of the study. They were selected using purposeful and snowball sampling .

By reviewing and analyzing the theoretical foundations, the dimensions and components of the human resources architecture model with the intelligentization approach were investigated and identified in TASEPI. The dimensions and components were sent to 20 experts. The proposed dimensions included 14 dimensions and 102 components, which were reduced to 12 dimensions and 94 components in the initial surveys of experts. Then, the Delphi panel was formed using two purposeful and snowball sampling methods. After three Delphi rounds, the desired dimensions and components were identified (Figure 1).

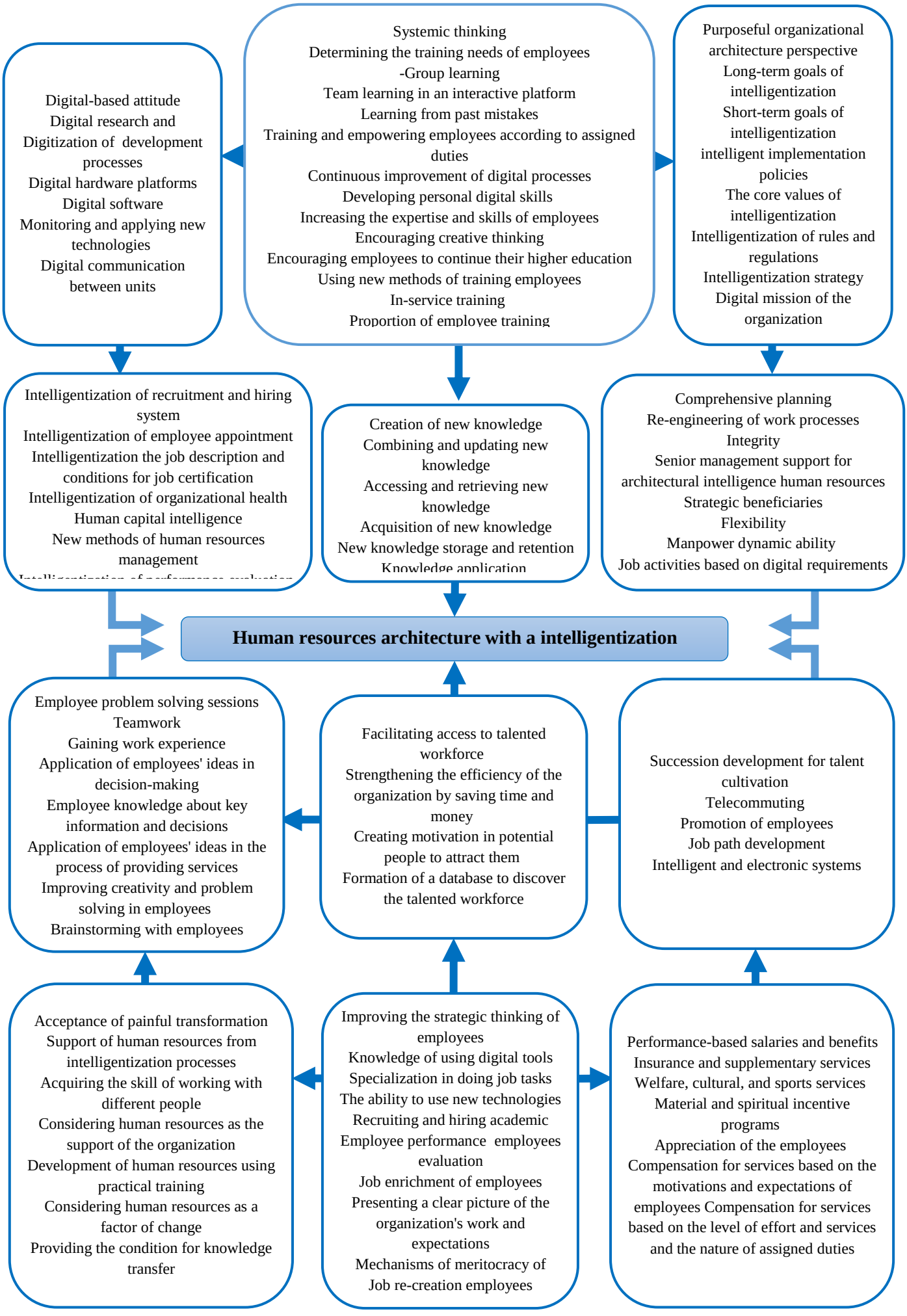


Figure 1. *Research conceptual model*

The second (quantitative analysis) stage: In this stage, the research method was a descriptive survey, correlational type. The statistical population in the qualitative section included 20 experts in related fields. The statistical population in the quantitative section included all managers and employees in TASEPI including Sistan and Baluchistan, Kerman, Hormozgan, and South Khorasan. Their total number was 840 people. Among them, 264 people were selected as a statistical sample. The researcher-made questionnaire was used to collect data. It included 12 key dimensions and 77 components of the two variables of human resource architecture and intelligentization. It was scored on a five-point Likert scale.

Statistical analysis

Confirmatory factor analysis, structural equation model, Smart PLS-3, and SPSS-22 software were used to confirm the measurement model and structural model validity. The analysis was done using t-statistics, factor loading, path coefficient, and coefficient of determination. In the general model of the study, as shown in Figure 1, the measurement model and path model were calculated. The t-statistic was calculated using the bootstrapping method to measure the significance of the relationships.

Results

Investigating the demographic information of Delphi panel members showed that 85% of the experts were male, 90% had doctorate degrees, 70% were university professors, and 55% had an employment history of 15 years and more. In addition, 60% were in the age group of below 40 years. In the quantitative stage, 67% of the respondents were male and 14.8% of them had a doctorate. Additionally, 23.5% had an employment history of 15 years and above and 66.3% were in the age group of above 35 years Table 1.

Table 1.

Demographic characteristics of qualitative study experts

Characteristics	Respondents	Frequency	Percentage of frequency
Gender	Female	3	15
	Male	17	85
Education	Master	2	10
	Doctorate	18	90
Job rank	University lecturer	14	70
	Senior manager	6	30
Employment history	10-15 years	9	45
	15 years and older	11	55
Age	Below 40 years	12	60
	40 years and older	8	40
Demographic characteristics of participants of the qualitative stage			
Gender	Female	87	33
	Male	177	67
Age	Less than 30 years	36	13.6
	31 to 35 years	53	20.1
	36 to 40 years	99	37.5
	40 years and older	76	28.8
Education	Bachelor	127	48.1
	Master	98	37.1
	Ph.D.	39	14.8
Employment history	Less than 5 years	46	17.4
	6 to 10 years	68	25.8
	11 to 15 years	88	33.3
	Above 16 years	62	23.5
total		264	100

The measurement model fit: To examine the measurement model fit, the data from the questionnaires were entered into the Smart PLS software.

Reliability: The reliability of the criteria is confirmed when its Cronbach's alpha is higher than 0.7. As seen in Table 2, Cronbach's alpha is higher than the recommended value for all 12 criteria, so the reliability of the criteria is confirmed.

Table 2.

Results related to the measurement model fit

Row	Cronbach's alpha	rho_A index	Composite reliability (CR)	Average variance extracted
organizational architecture intelligent strategy	0.884	0.889	0.908	0.553
Human resources intelligent management	0.868	0.927	0.907	0.586
Human resources intelligent system	0.913	0.916	0.930	0.625
Core technology	0.873	0.881	0.905	0.614
Intelligent organizational learning	0.841	0.886	0.880	0.598
Intelligent knowledge management	0.889	0.897	0.913	0.600
Human resource intellectualization	0.939	0.940	0.948	0.672
Intelligent employee engagement	0.894	0.903	0.918	0.617
Creating new human resources roles	0.838	0.844	0.903	0.756
Talent treasury formation	0.836	0.840	0.891	0.671
Advanced functional activities	0.836	0.852	0.891	0.674
Human resource retention activities	0.888	0.890	0.918	0.691

Composite reliability: Composite reliability of each criterion is confirmed when its value is higher than 0.7. As seen in Table 2, its value is higher than the recommended value for all 12 criteria, so the composite reliability of the measurement model is confirmed.

Convergent reliability (AVE): The convergent reliability of each criterion is confirmed when its value is higher than 0.5. As seen in Table 3, the AVE value for all 12 criteria is higher than the recommended value, so the convergent validity of the measurement model is confirmed.

Composite reliability (CR): Composite reliability is confirmed when its value is higher than AVE. As seen in Table 3, the composite reliability of the measurement model is also confirmed.

Divergent validity: In examining the divergent validity (Fronell-Larcker criterion), if it is found that the correlation between an index and another structure other than its own structure is higher than the correlation of that index with its own structure, the divergent validity of the model is doubted. For this purpose, a matrix should be formed, which is the original diameter of the root matrix of the AVE coefficients of each structure and the lower values of the original diameter of the correlation coefficients between each criterion and other criteria. As seen, the correlation of each criterion with its related components is higher than the correlation of each criterion with other criteria, so the model's divergent validity is confirmed.

Table 3.

Results related to divergent validity

Divergent validity Fronell-Larcker criterion	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
organizational architecture intelligent strategy	0.912											
Human resources intelligent management	0.900	0.929										
Human resources intelligent system	0.744	0.896	0.923									
Core technology	0.879	0.784	0.873	0.905								
Intelligent organizational learning	0.884	0.895	0.903	0.887	0.953							
Intelligent knowledge management	0.264	0.250	0.243	0.286	0.353	0.775						
Human resource intellectualization	0.871	0.913	0.906	0.895	0.820	0.264	0.923					
Intelligent employee engagement	0.891	0.765	0.907	0.891	0.907	0.255	0.912	0.917				
Creating new human resources roles	0.858	0.869	0.851	0.898	0.851	0.222	0.828	0.785	0.908			
Talent treasury formation	0.819	0.871	0.887	0.844	0.706	0.276	0.903	0.898	0.894	0.970		
Advanced functional activities	0.790	0.877	0.891	0.821	0.860	0.312	0.890	0.888	0.808	0.861	0.910	
Human resource retention activities	0.894	0.878	0.901	0.843	0.912	0.223	0.831	0.862	0.850	0.837	0.859	0.926

The structural model fit: To examine the structural model fit, two statistics are used. One is the significance coefficient z. It means the t-value should be higher than 1.96. As seen, this value is much higher than the recommended value for all 12 criteria. Also, the R2 value of all twelve criteria is more than 0.5, so the structural model it is also confirmed Table 4.

Table 4.

Results of structural model fit

Row	**significance coefficient z**	**R2 values**
organizational architecture intelligent strategy	164.01	0.908
Human resources intelligent management	217.28	0.922
Human resources intelligent system	212.57	0.932
Core technology	176.81	0.893
Intelligent organizational learning	204.83	0.913
Intelligent knowledge management	5.97	0.123
Human resource intellectualization	321.26	0.949
intelligent employee engagement	265.39	0.932
Creating new human resources roles	86.26	0.803
Talent treasury formation	111.73	0.900
Advanced functional activities	105.95	0.859
Human resource retention activities	218.87	0.926

Presenting the structural model: In the general model of the study shown in Figure 2, the measurement model (the relationship between each of the observed variables and the latent variable) and the path model of the relationship between the latent variables were calculated. To measure the significance of relationships, the t-statistic was calculated by the bootstrapping method, as shown in Figure 5. This model, which is the output of Smart PLS software, presents a summary of the results related to the standard factor load of the relationships of the research variables.

Figure 2.

The path coefficient of the primary research model for the dimensions of human resources architecture with the intelligentization approach

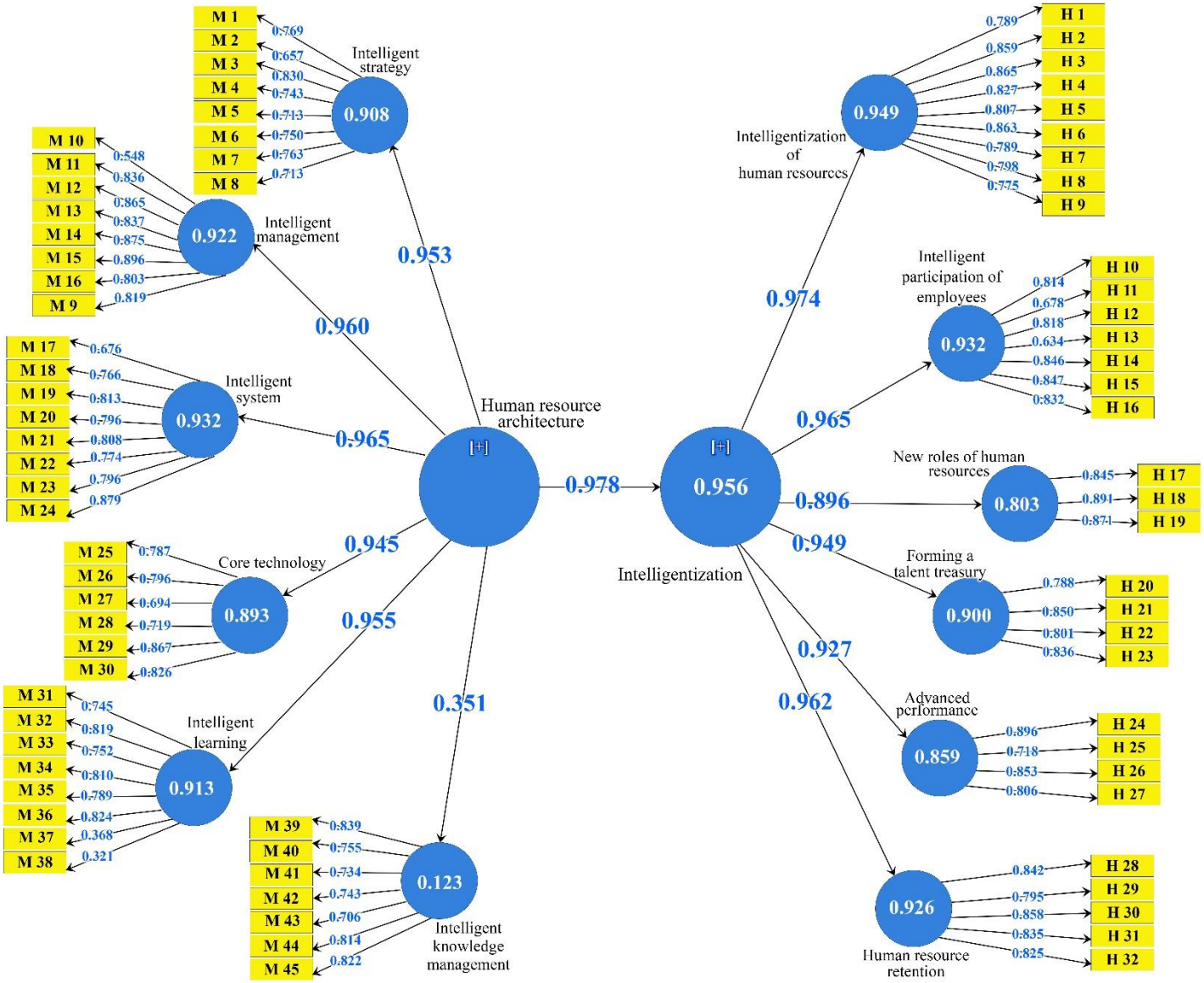
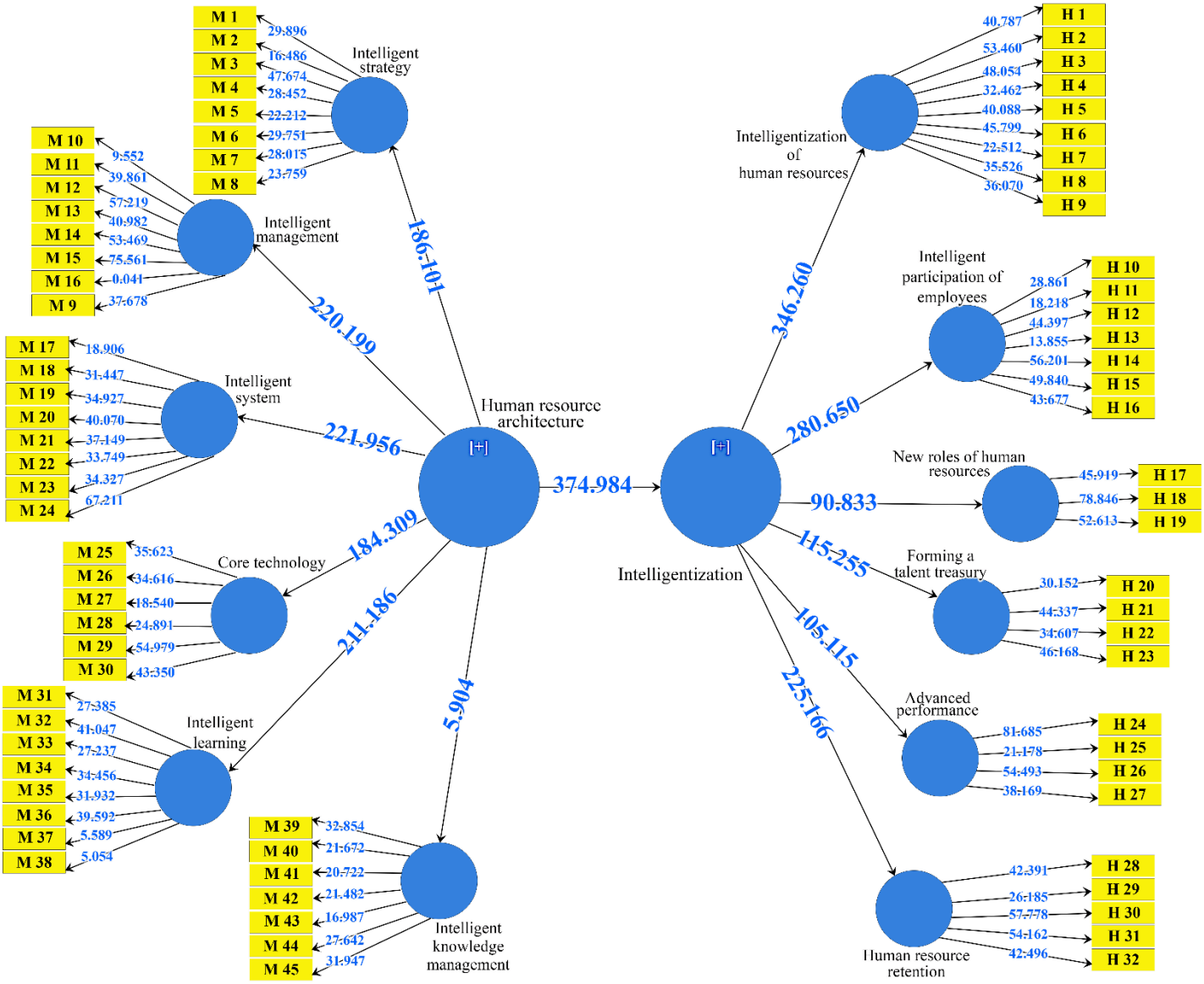


Figure 3 shows the factor load of the dimensions of human resources architecture and intelligence and their components. It shows the impact of each dimension in human resource architecture and intelligence.

Figure 3.

T-statistics of the primary research model for dimensions of human resource architecture and intelligence



The figure above also shows the t-statistic for all six dimensions of human resources architecture and six dimensions of human resources architecture. According to the results of the factor load, the order of all six dimensions of human resources architecture in terms of importance in TASEPI is intelligent human resources system (0.953), intelligent human resources management (0.960), intelligent organizational learning (0.955), intelligent organizational architecture strategy (0.953), core technology

(0.945), and intelligent knowledge management (0.451), respectively.

The priority of the components of each dimension of human resources architecture

Table 5.

Factor load and t-statistic for the components of each dimension of the human resources architecture model

Dimensions	Component	Factor load	t-statistic	rank
Intelligent strategy of organizational architecture	Intelligent organizational architecture perspective	0.769	28.74	2
	Long-term goals of intelligence	0.657	16.83	7
	Short-term goals of intelligence	0.830	45.06	1
	intelligent implementation policies	0.743	28.16	5
	The core values of intelligence	0.713	21.74	6
	Intelligentization of rules and regulations	0.750	28.75	4
	Intelligentization of strategy	0.763	24.89	3
	The organization's digital mission	0.713	23.59	6
Intelligent human resource management	Intelligentization of the recruiting and hiring system	0.819	38.64	6
	Intelligentization of the appointment of employees	0.548	10.00	7
	Intelligentization of job description and job qualification conditions	0.836	40.35	5
	Intelligentization of organizational health	0.865	60.93	3
	Intelligentization of human capital	0.837	40.53	4
	New methods of human resource management	0.875	54.68	2
	Intelligentization of performance evaluation	0.896	71.00	1
	Human resource improvement	0.410	4.04	8
Human resources intelligent system	Comprehensive planning	0.676	18.73	7
	Reengineering work processes	0.766	33.21	6
	integrity	0.813	35.30	2
	Senior management support for the intelligentization of human resources architecture	0.796	39.32	4
	Strategic stakeholders	0.808	33.82	3
	Flexibility	0.774	32.71	5
	Human resource dynamics	0.796	33.48	4
	Job activities based on digital requirements	0.879	62.67	1
Core technology	Digital research and development	0.787	31.91	4
	Digitalization of processes	0.796	36.02	3
	Digital hardware platforms	0.694	18.65	6
	Digital software	0.719	24.60	5
Intelligent organizational learning	Monitoring and applying new technologies	0.867	56.81	1
	Digital communication between units	0.826	44.59	2
	Systems thinking	0.745	27.38	6
	Team learning	0.819	39.61	2
	Learning from past mistakes	0.752	28.70	5
	Continuous improvement of digital processes	0.810	35.64	3
	Developing personal digital skills	0.789	30.89	4
	Encouraging creative thinking	0.824	37.74	1
	Encouraging employees to continue higher education	0.368	5.66	7
	In-service training	0.321	4.96	8
Intelligent knowledge management	Creation of new knowledge	0.839	32.18	1
	Combining and updating new knowledge	0.755	23.18	4
	Access and retrieval of new knowledge	0.734	20.43	6
	Acquisition of new knowledge	0.743	21.26	5

Dimensions	Component	Factor load	t-statistic	rank
	New knowledge storage and retention	0.706	16.54	7
	knowledge application	0.814	26.86	3
	Free flow of knowledge	0.822	31.67	2

The results revealed that all the components of the presented model dimensions were in line with the human resource architecture in TASEPI. The "short-term goals of the intelligentization" component was ranked first in the dimension of the intelligent strategy of organizational architecture. The intelligentization of the performance evaluation component was ranked first in the dimension of the intelligent human resources management component. The component of job activities based on digital requirements was ranked first in the intelligent human resource system" dimension. The component of encouraging creative thinking was ranked first in the dimension of intelligent organizational learning. The component of the creation of new knowledge was ranked first in the dimension of intelligent management of knowledge (Table 5). Based on the results, the order of intelligentization dimensions in terms of importance is the intelligentization of human resources, intelligent participation of employees, activities to human resource retention, formation of talent treasury, advanced functional activities, and the creation of new roles of human resources.

The priority of the components of each dimension of intelligence

According to the results, all the components of the presented model dimensions were in line with the intelligentization in TASEPI. In the dimension of intelligentization of human resources, the component of specialization in performing job tasks was ranked first. In the dimension of intelligent participation of employees, the component of improving creativity and problem-solving in employees was ranked first. In the dimension of the creation of new roles of human resources, the component of considering human resources as the organization's driving force was ranked first. In the dimension of the formation of the talent treasury, the component of strengthening the efficiency of the organization by saving time and money was ranked first. In the dimension of advanced functional activities, the component of talent cultivation and succession development was ranked first. In the dimension of human resource retention activities, the component of welfare, cultural, and sports services was ranked first (Table 6).

Table 6.

Factor load and t-statistic for the components of each dimension of the intelligentization of the model

Dimensions	Component	Factor load	t-statistic	Rank
Intelligentization of human resources	Improving the strategic thinking of employees	0.789	36.15	8
	Knowledge of applying digital tools	0.859	51.59	3
	Specialization in doing job tasks	0.865	44.55	1
	The skill of using new technologies	0.827	32.48	4

Dimensions	Component	Factor load	t-statistic	Rank
Intelligent participation of employees	Recruiting and hiring knowledge workers	0.807	38.29	5
	Job enrichment of employees	0.863	44.63	2
	Employee meritocracy mechanisms	0.789	22.29	7
	Job re-creation	0.798	35.99	6
	Knowledge force retention	0.775	35.27	9
	Employee problem-solving sessions	0.814	29.92	5
	teamwork	0.678	17.85	6
	Application of employees' ideas in decision making	0.818	41.09	4
	Employee knowledge about key information and decisions	0.634	13.52	7
	Application of employees' ideas in the service delivery process	0.846	53.34	2
Creating new human resources roles	Improving creativity and problem-solving in employees	0.847	48.31	1
	Brainstorming sessions with employees	0.832	41.75	3
	Human resource support for the intelligentization process	0.845	44.02	3
	Considering human resources as the driving force of the organization	0.891	81.85	1
	Considering human resources as a change agent	0.871	50.25	2
Forming a talent treasury	Facilitating access to talented workforce	0.788	31.97	4
	Strengthening organization efficiency by saving time and money	0.850	46.54	1
	Motivating talented people to hire them	0.801	33.44	3
	Formation of a database to discover the talented workforce	0.836	44.81	2
Advanced functional activities	Succession development of talent cultivation	0.896	80.24	1
	Teleworking	0.718	21.69	4
	Job promotion of employees	0.853	53.62	2
	Intelligent and electronic systems	0.806	37.65	3
Human resource retention activities	Performance-based salaries and benefits	0.842	41.41	2
	Insurance and supplementary services	0.795	25.48	5
	Welfare, cultural, and sports services	0.858	59.72	1
	Material and spiritual incentive programs	0.835	56.26	3
	Compensation for services based on the motivations and expectations of employees	0.825	43.10	4

Discussion

The results showed that among the dimensions of "human resources architecture", the "intelligent human resource system" dimension has the highest impact on "human resources architecture" so one unit of change in the "intelligent human resource system" dimension caused 0.965 changes in the human resource architecture. This result is consistent with the results of studies conducted by Bogićević (2020), Delveji et al. (2014), Rezaei et al. (2015), and Rouhani et al. (2022). In explaining this result, it can be stated that human resources can process other resources and provide the services and goods for which the organization was established. The intelligent human resource system can predict and provide the volume and composition of human resources needed for the future or improve the capabilities of existing forces through efficient planning. Thus, human resources planning should have a high priority for the continuation of the organization's life and achieving its goals.

According to the results, among the dimensions of "human resources

architecture", the dimension of "intelligent human resources management" was ranked second regarding its effect on human resources architecture, so one unit of change in the "intelligent human resources management" dimension caused 0.960 changes in human resources architecture. This result is consistent with the results of studies by Seded Javadin (2014), Nourafza et al. (2019), Yazdan Panah et al. (2021), Agarwal et al. (2022), Bersin (2018), Boon et al., (2017), and Lee et al. (2019). In explaining these results, it can be stated that the new perspective prevailing in current organizations emphasizes that every organization needs a specific human capital that has high strategic and unique value creation, and the organization's human resource managers should be adapted to these key people. The mechanism of transferring organizations from a traditional job-oriented perspective to a new knowledge-oriented perspective is called intelligent human resource management. Intelligentization of the management of human resources in the organization is a fundamental and time-consuming process. A clear example of the digital revolution is the acceptance of the expansion of digital human resources systems, which has converted human resources into intelligent platforms.

The results suggest that among the dimensions of "human resource architecture", the dimension of "intelligent organizational learning" dimension was ranked third in affecting human resource architecture, so one unit of change in the intelligent organizational learning dimension caused 0.955 changes in the human resource architecture. In explaining the results, it can be stated that learning significantly contributes to an organization's performance and survival. The intelligent learning process is a continuous cycle of activities of feeling, environment understanding, and the interpretation of the environment based on past experiences and practical action based on the environment interpretation.

Generally, investment in the process of organizational learning and knowledge management in companies and organizations to maintain its position is considered one of the important ways that the organization can continuously use to create and improve knowledge management. According to the results, among the dimensions of human resources architecture, the dimension of the intelligent strategy of organizational architecture was ranked fourth rank in affecting the architecture of human resources, so one unit of change in the dimension of the intelligent strategy of organizational architecture caused 0.953 changes in human resources architecture. This result is consistent with the results of studies by Anand, Arsalan, and Bowden (24-26). In explaining the results, it can be stated that the goal of intelligent strategy of organizational architecture is beyond the alignment of information technology with business or the modernization of information technology, and the flow of architecture from strategy to implementation is considered. Also, the change in strategic levels and the business transformation is emphasized not only in the technical architecture of information systems. Thus, the important characteristic of the intelligent strategy of organizational architecture is the level of importance of the issues examined and decision-making.

The results suggest that among the dimensions of human resources architecture, the dimension of core technology was ranked

fifth in affecting human resources architecture so one unit of change in the dimension of core technology caused 0.945 changes in human resources architecture. This result is consistent with the results of studies by Harpaz and Mashulem (2010), Vrontis et al. (2022), Lee et al. (2019), Boon et al. (2021), Seyed Javadin et al. (2014), and Ghorbani Nasrabadi et al. In explaining the result, it can be stated that one of the organizational components affecting the human resources management system is the organization's core technology, so organizational and human resource management system officials and managers always consider the core technology of the organization in the design, implementation, and evaluation stages of this vital system of the organization. They are trying to be aware of the status and type of their core technology, design a resource management system, and implement it based on the core technology type.

According to the results, among the dimensions of human resource architecture", the intelligent knowledge management dimension was ranked sixth in affecting human resource architecture so one unit of change in the intelligent knowledge management dimension caused 0.451 changes in the human resource architecture. This result is consistent with the results of studies by Istuder et al. (2016), Yazdan Panah et al. (2014), Rezaei et al. (2014), Rouhani et al. (2022), and Seyed Javadin et al. (2014) In explaining this result, it can be stated that organizations will be successful in knowledge management if they can manage their knowledge more intelligently. Artificial intelligence will change executive and operational approaches in many industries. Thus, knowledge management officials must pay attention to it as one of the vital components in the growth and learning of organizations. For this purpose, it is essential to pay attention to artificial intelligence in the implementation of knowledge management. Improving access to knowledge is one of the benefits of using artificial intelligence in knowledge management.

The results indicate that among the dimensions of "intelligentization", the dimension of "intelligentization of human resources" has the highest impact on "intelligence" so one unit of change in the dimension of "human resource intelligence caused 0.974 changes in intelligentization. This result is consistent with the results of several studies in explaining these results, it can be stated that using sensors, collecting information from big data, and using artificial intelligence and automation of work processes help the development of intelligent human resource management. Intelligent tools directly affect the quality and comprehensiveness of human resources subsystems, including planning the supply of workforce at the required time, real data to evaluate the performance of employees, the development process, and update and online training.

According to the results, among the dimensions of "intelligentization", the dimension of "intelligent participation of employees" was ranked second in affecting "intelligentization" so one unit of change in the "intelligent participation of employees" dimension caused 0.965 changes in intelligentization. This result is consistent with the results of studies by Fench et al. (2019), Vrontis et al. (2022), Ghorbani Nasrabadi et al. (2021), Seyed Javadin et al. (2013), and Ghasemi et al. (2021). In explaining the results, it can be stated that

human and intellectual capital in intelligent human resources is the primary source that helps to achieve organizational goals and the effectiveness of its methods in standardizing human resources. Intelligent human resources are utilized in a management environment with the help of primary resources to understand a situation and implement the necessary solutions and instructions. Thus, it is essential to focus on the capabilities of employees based on the rules set in each organization.

The results indicate that among the dimensions of "intelligentization", the dimension of "human resources retention activities" was ranked third in affecting "intelligentization" so one unit of change in the "human resource retention activities" dimension caused 0.962 changes in intelligentization. This result is consistent with the results of studies by Fench et al. (2019), Lee et al. (2019), and Rouhani et al. (2022), Nourafza et al. (2022).

In explaining the results, it can be stated that human resources can process other resources and provide services and goods for which the organization was established. The intelligent human resources system can predict and provide the volume and composition of human resources needed for the future or improve the capabilities of existing forces through efficient planning. According to the results, among the dimensions of "intelligentization", the dimension of "creating talent treasury" was ranked fourth in affecting "intelligentization" so one unit of a change in the dimension of "creating talent treasury" caused 0.949 changes in intelligentization. This result is consistent with the results of several studies (17, 32, 14, and 23). In explaining this result, it can be stated that a skilled workforce or a suitable job in the new world is mostly found in various collective and specialized events. Forming a talent treasury is one of the best ways to facilitate access to a talented workforce, and large organizations can attract the best specialists in their field by using the talent treasury.

The results indicate that among the dimensions of "intelligentization", the "advanced functional activities" dimension was ranked fifth in affecting "intelligentization" so one unit of change in the "advanced functional activities" dimension caused 0.927 changes in intelligentization. This result is consistent with the results of studies by Vrontis et al. (2022), Ghorbani Nasrabadi et al. (2021), Seyed Javadin et al. (2014), and Yazdan Panah et al. (2014). In explaining this result, it can be stated that to increase performance efficiency, employees should acquire extensive information about advanced workplace design to promote health, purposefulness, and correct interaction with their employees using modern communication tools. Resource management focuses on controlling human resources to achieve the maximum potential of employees.

According to the results, among the dimensions of "intelligentization", the dimension of "creating new roles of human resources" was ranked sixth in affecting "intelligentization" so one unit of change in the dimension of "creating new roles of human resources" caused 0.895 changes in intelligentization. This result is consistent with the results of studies by Fench et al. (2019), Lee et al. (2019), and Rouhani et al. (2021). In explaining the result, it can be stated that since business managers are facing unprecedented changes in the field of human

resources, to overcome these challenges and adapt to new demands, they should improve their information on intelligent human resources. Thus, it is essential to develop digital human resource training so organizational performance is adapted to these changes.

Nowadays, organizational architecture creates a comprehensive road map at the organizational level for the realization of the organization's missions through the optimal functioning of its primary processes in an effective information technology environment. Thus, organizational architecture is necessary for the evolution of current information systems and the formation of new systems in line with the realization of the organization's missions. Additionally, intelligence is a human characteristic that can be seen in the performance of people, but it has also extended to organizations in the current organization-oriented world.

In the digital transformation and knowledge-oriented age, organizations need employees who have enough intelligence to understand and analyze issues. Employees of organizations should be able to receive and analyze rich data and information from various sources. Success in the competitive arena will be guaranteed for organizations that have capable people with sufficient knowledge and insight. Intelligent human resource management is a concept that has emerged as a part of digital transformation in the issues related to human resource management or organizational approaches such as learning, sharing knowledge, developing job skills, etc.

Intelligent human resources have many indicators, the most important of which are data-oriented and data analysis capabilities, especially in human resources.

Recommendations

Based on the results, it is recommended that managers should make more efforts in developing the vision horizon of intelligent organizational architecture and the digital mission of the organization in line with the intelligentization implementation policies. It is also recommended that managers pay more attention to the development, implementation, and evaluation of effective strategies in the intelligentization of recruitment and hiring system, job description, conditions of job qualification, appointment of employees, strengthening intelligent organizational learning by improving systemic thinking, team learning, and learning from past mistakes.

Conclusion

The managers of the Tax Administrations should develop a vision horizon of intelligent organizational architecture in line with the intelligentization implementation policies and plan to acquire new technologies in the area of artificial intelligence and use them in creating intelligent organizational architecture.

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RESEARCH ARTICLE **Open Access**

A Meta-synthesis of Studies on Elite Retention in Organizations

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Abstract
Retaining an organization's elites is a major challenge in human resource management. Elites represent intellectual capital and drive innovation in organizations; their loss can significantly undermine organizational productivity and growth. This study employed a meta-synthesis qualitative method to analyze factors influencing elite retention, systematically reviewing 682 papers and selecting 23 based on inclusion criteria. Content analysis identified 304 initial concepts, categorized into 20 sub-concepts and 10 main themes, validated via CASP checklist and expert verification, with reliability assessed using Cohen's kappa coefficient. Findings highlight that organizations evolving rapidly benefit substantially from elite contributions, particularly in knowledge production and scientific advancement. Leveraging elites' capabilities not only enhances organizational development but also fosters their motivation, creating a symbiotic growth dynamic. The study underscores the need for strategic retention mechanisms tailored to elite employees' intellectual and motivational drivers, offering a framework for HRM practitioners to mitigate attrition risks and harness elite potential effectively.

Keywords: *Retention, Elite, Human capital, Meta-synthesis*

Introduction

Nowadays, it is essential for organizations to continuously improve their performance so as to survive and progress in the competitive world. Human resources, on the other hand, can be seen as one of the most significant organizational resources to reach this important matter. Modern organizations have come to realize that attending to human resources, their management, and establishing a comprehensive human resources system could widely affect other parts of their organizations (Sarshar and Samiei, 2010). In the existing competitive situation and in an environment where continuous changes and continuous innovations are its major characteristics, only organizations will succeed in achieving excellence that understand the strategic role of their human resources and have skilled, knowledge-based, competent, elite, and capable human resources (Sarafraz et al., 2019). Human resources are considered the primary asset of any institution or organization, and when competent, they can ensure the organization's success and excellence. Forward-thinking and leading organizations consistently strive to develop and implement comprehensive programs to ensure the attraction, retention, and development of their talented and elite employees (Aalders et al., 2023).

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One of the main priorities of today's organizations in the modern era is to find and retain human capital due to the intense competition and a lack of highly skilled and capable employees (Febrian et al., 2023). The strategic and economic advantage in the future will indubitably go to organizations that can attract, cultivate, and retain the best and brightest human capital better than others in the labor market. Therefore, the challenge that organizations face today is attracting, excelling, and retaining human capital (Chen et al., 2023). In actual fact, if human resources are considered as a competitive advantage for organizations and human resources costs as an investment, attracting quality employees and, most importantly, attracting and retaining elites will be placed as a priority. Elite employees assist an organization with planning, directing, and controlling affairs, and they ensure the organization's success and subsequently reduce the organization's costs by providing effective, unparalleled, and shortcut solutions (Shahlaei, 2016).

Support and retention of human resources is a set of management measures and actions providing the ground for human resources to stay and be retained in an organization. Retention refers to maintaining the security, morale, interest, and professional capability of individuals (Karrar & Zardashtian, 2010). The fundamental goal in attracting and retaining elites in an organization is to create strategic capability and ensure that the organization has elite employees who are motivated enough to achieve a sustainable competitive advantage. Elite management is much more than human resource management; eliteness and elitism are attitudes that should prevail at all levels of a company or organization. Elite management is not a goal per se, and it is not limited to employee development or succession planning, nor is it related to achieving specific tactical goals. In fact, elite management has been created to support the overall goals of an organization (Kim & McLean, 2012).

Evidence suggests that elite talent management encompasses multiple dimensions, among which six are of particular importance. Each of these dimensions includes specific strategies and methods which, when integrated both within and across dimensions, constitute a comprehensive elite management process (Moghimi & Memarzadeh, 2022). The first dimension involves growth and development strategies. These long-term strategies are designed to attract, develop, connect, and ultimately utilize the workforce. The second dimension concerns the attraction and retention of elite talent. In this dimension, the required competencies are defined based on organizational needs, and individuals possessing such competencies are identified, recruited, and supported. The third dimension relates to motivation and empowerment, in which individuals' abilities and talents are nurtured in alignment with organizational needs, while also addressing personal needs such as motivation, personal development, and satisfaction. The fourth dimension pertains to deployment and management, ensuring that individuals are placed in appropriate positions based on their capabilities and talents, with managerial focus directed toward enhancing their performance in these roles. The fifth dimension emphasizes connecting and empowering elite individuals and networks. In this dimension, individuals with related talents and competencies are linked together

to engage in collaboration and knowledge exchange. These connections, even if virtual, play a significant role in enhancing the organization's social capital and advancing its objectives. Finally, the sixth dimension focuses on change and sustainability, aiming to achieve transparent, measurable, and lasting change within the organization while maintaining day-to-day operations (Ewerlin & Sü, 2017). A key consideration in elite retention is the extent to which an organization needs to utilize elite capabilities. Each organization, based on factors such as size, market position, and scope of activity, must define its required level of elite talent and accordingly formulate its strategies and policies in this area. It is of great importance to paying attention to elite retention in organizations, as Armstrong and Brown (2019) and Gagne (2015) have emphasized the need to retain elites in organizations for efficiency. Also, Foster et al. (2014), Afjeh and Ghaffari (2013) have also pointed out in their research findings that elite retention is essential for achieving excellent organizational performance.

Hence, the challenge that organizations face today is to retain elites in organizations. In fact, the lack of talent and elites is the biggest obstacle to the growth of organizations, and compensating for this deficiency is considered a major strategic advantage. Based on statistics published by global organizations, human capital with 77% accounts for the leading role in wealth creation in developed countries, compared to the combined share of natural and physical resources in these countries, which is 23% (Park, 2022). Certainly, elite retention is recognized as one of the most significant and important issues in human resource management in organizations. With a little reflection on the statistics presented in this regard, it can be found that the economic factor has played an indisputable role in this issue. However, in order to find its root cause, we undoubtedly need to look for factors beyond economic problems. In general, according to what was mentioned above, the need for a comprehensive and systematic approach to the issue of identifying and classifying the factors affecting elite retention in organization is felt more than ever. Thus, the researcher in this study decided to identify the aspects affecting elite retention in organizations and develop a conceptual model for it using a qualitative method with a metasynthesis approach, which is a novel and systematic method.

Methodology

This study is qualitative research conducted using the metasynthesis method based on Sandelowski and Barroso's approach (2006). Metasynthesis is a type of meta-study research method investigating findings extracted from different qualitative studies with similar and related topics and providing a systematic approach for researchers to discover new topics and metaphors by combining multiple studies, thereby expanding current knowledge and creating a comprehensive view of the issues (Ring et al., 2010). Its metasynthesis stages consist of determining the research objective and question, systematically studying the literature, searching for and selecting proper texts, extracting information from papers, analyzing and combining the findings from the studies, quality control, and presenting the findings. These stages are discussed in detail below.

Findings

Stage 1: Developing the research question

In this step, as the first stage of the metasynthesis study, to determine the main objective of the research and to develop and achieve the fundamental research question, various criteria such as what, who, when, and how are considered. Accordingly, to answer the question of "what", based on the conducted investigations, the research addressing the aspects and components affecting elite retention in organizations were studied. Regarding the question of "who", the majority of the works were scientific-research papers published in domestic and foreign journals in English and Persian, which were studied with a qualitative approach. As for the question "when", the selected time period for the studies is from March 21, 2009 to March 19, 2024. Finally, concerning the question "how", which reflects the method chosen by the researcher to collect data, in this study, the findings of qualitative studies related to the subject were analyzed using the content analysis method. Given the above-mentioned materials, the explored fundamental research questions are as follows:

What are the aspects affecting elite retention in organizations?

Stage2: Systematic literature review

The statistical population of this study includes all published papers conducted in the subject area under study. A systematic electronic search of resources was conducted based on the keywords "elite retention", "organizational elites", "elite-oriented organization", "elite management in organizations" and "support and attraction of elites" in domestic scientific databases such as the Scientific Information Database of Jihad Daneshgahi (Sid.ir), the National Publications Database (Magiran.com), the Noor Specialized Magazines Database (Noormags.ir), the Comprehensive Portal of Humanities (Ensani.ir) as well as in foreign scientific databases such as ScienceDirect, Google Scholar and Proquest, etc. In order to determine bounds for the search, the following criteria were considered:

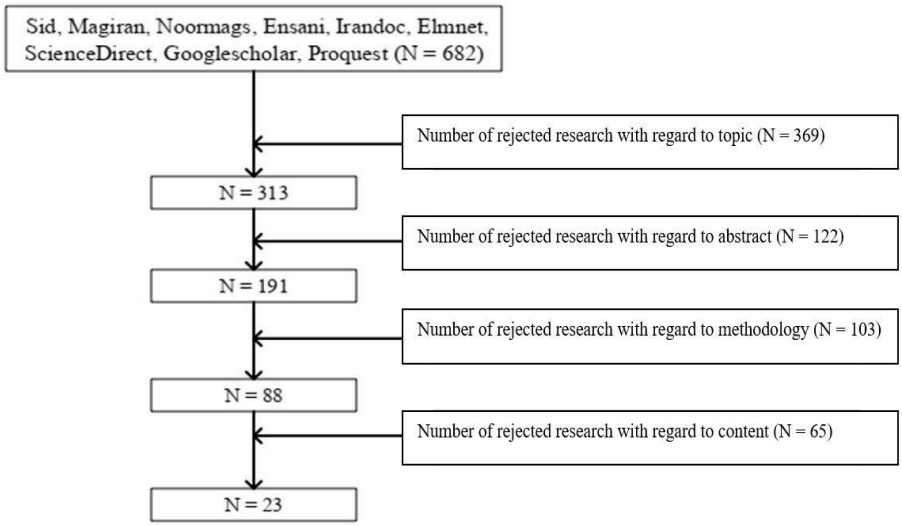
1) Of various scientific texts, including national and international conference papers, conference papers, scientific-promotional papers, and scientific-research papers, only scientific-research papers published in domestic and foreign journals were searched.
2) The time period of the research was considered from March 21, 2009 to March 19, 2024.
3) Research with full text available was selected.

Stage 3: Search and selection of proper texts

After an extensive search in various scientific databases, 682 studies (domestic: 286, foreign: 396) associated with elite retention in organizations were identified. In order to select proper and reviewable studies in metasynthesis, the titles, abstracts, methodologies, findings, and research contents of the identified studies were evaluated so that studies whose methodologies and findings were quantitative and also studies whose full texts were not available were eliminated from the research stages. Finally, 23 studies were considered as the basis for the metasynthesis study in this research. The process of this selection is illustrated in Figure 1.

Figure 1.

Research selection process



Stage 4: Extracting data from texts

In this step, the studies selected in the previous step were examined using content analysis and contents and concepts related to elite retention in organizations were identified as the main codes. Bengtsson (2016) believes that content analysis is an appropriate method for summarizing, describing, and interpreting data from qualitative research. The results of this step are shown in Table 1.

Table 1.

Identified components related to organizational ambidexterity

Code	Author	Extracted components
1	Sarafaraz et al. (2019)	Reward and recognition, meritocracy, family respect, preserving dignity and honor, psychological characteristics, organizational support, organizational culture, participation, justice, organizational characteristics, satisfaction, commitment, knowledge sharing, risk-taking, individual characteristics, role quality, challenging role, job independence, job characteristics
2	Shateri et al. (2015)	Satisfaction with direct supervisor, organizational culture, clear organizational mission and vision, acceptance of talents, support from senior managers and upstream documents, provision of opportunities for growth and prosperity, organizational atmosphere, organizational image and brand, organizational justice, type and level of colleagues, sense of dynamism in organizations, working conditions
3	Zandi et al. (2019)	Creating job opportunities, providing job security, promoting economic welfare, work independence, promoting social welfare, downsizing organizations, meritocracy, welfare facilities, granting research credits, organic structure, organizational culture, job prestige
4	Nikmanesh et al. (2023)	Relations with knowledge-based centers, relations with international scientific centers, support for creativity and innovation, financial support, meritocracy, justice-based evaluation, performance-based promotion, elite-based recruitment, creation of intellectual property, organic organizational structure, elimination of complex bureaucracies, organizational visions and strategies to retain elites, support for the private sector, transparency, approval of supporting laws and policies.
5	Tahmasebi et al. (2012)	Opportunities for professional and practical development, availability of facilities and financial resources, conditions for carrying out scientific activities, availability of job security, participation in staff affairs, support for family

Code	Author	Extracted components
		members, creation of suitable working conditions, branding, professional and personal development, suitable conditions of the physical environment
6	Khaki & Hosseini (2022)	Flexibility in working hours, teleworking, suitable physical conditions, study opportunities, teamwork, sense of belonging and permanence to organizations, material and non-material support, organizational commitment, career attitude
7	Khanifar et al. (2020)	Knowledge development, employing elites, training elites, job dynamism, satisfaction and retention, compensation, support from senior managers, supportive management, appropriate working conditions, job rotation, determining path, job security and satisfaction, salaries and fringe benefits, in-service training, knowledge management, competency-based performance evaluation, training courses and workshops, vision, competent managers, succession planning, creating research opportunities, supporting research, retention strategies, alignment with organizational strategies
8	Arvand & Qods (2021)	Transparency in organizational regulations, supportive attitude of managers, communication between elites and managers, creating value for elites, reducing organizational hierarchy and creating an organic structure, management style, accountability, meritocracy, effective evaluation, determining the path and explaining goals, sharing knowledge, communication with educational centers, appropriate foresight, creating a group atmosphere and increasing cooperation, creating conditions for knowledge sharing, compensation for service, salaries and fringe benefits, workplace security, developing interactions with other organizations, promoting communications within the organization, granting special financial privileges, supporting creativity and ideation, creating conditions for creativity and presenting new ideas.
9	Naeem Yavari et al. (2017)	Organizational support for elites, organization's response to elite needs, increasing the organization's trust in elites, meritocracy, strategic planning to retain elites, performance-based evaluation, creating areas for growth and development for elites, granting financial resources, meeting elite needs, manager support, simple and broad organizational structure, foresight, flexible time, value creation and enhancing the status of elites in organizations, material and non-material motivation of elites.
10	Taghizadeh Yazdi et al. (2018)	Organizational credibility, organizational international image, organizational reputation and credibility, granting resources for research, supporting creativity and ideas of elites, work–life balance, creating appropriate opportunities for research and investigation, supporting scientific achievements of elites, workplace security, flexible time, attention to the needs of family members, organizational dynamism, financial support, management style.
11	Moradi & Shokri (2022)	Work–life balance, salaries and fringe benefits, allocation of financial privileges, foresight, promotion of organizational trust, support for elite ideas, meritocracy, justice-based evaluation, establishment of a distributive justice system, transparency in policies and laws, knowledge sharing, management system, support for managers, communication with managers, elite participation and cooperation, increased cooperation and teamwork.
12	Rezaian et al. (2018)	Attending to talents and creating opportunities for competition, creating opportunities to present new ideas, commercializing elite ideas, elite responsibility and commitment, organizational culture, teamwork and attending to group cooperation, meritocracy, performance-based evaluation, determining the path of progress, setting goals, strategic planning, and performance-based payment, delegating authority to elites, financial and non-financial incentives.
13	Tabaqdehi Hosseini (2020)	Participation in decision-making, delegation, job independency, performance-based rewards, participation in goal-setting in the organization, job rotation, sense of usefulness, job enrichment
14	Zahedi & Eshraghi (2021)	Person–organization fit, compensation and value creation for elites, training and career development, job promotion, performance-based evaluation, management system, delegation, employing elites in the headquarters department, satisfactory work environment, participation and communication, knowledge sharing
15	Bamdad Soofi & Emamat (2018)	Freedom of action for elites, participation of elites in organizational decisions, creativity and innovation, organizational credibility and reputation, payment and compensation system, job security, creating opportunities for advancement,

Code	Author	Extracted components
		granting special facilities and privileges, creating research opportunities, paying attention to needs of family members.
16	Ahmadi et al. (2017)	Organizational culture, teamwork, appreciation and encouragement, workplace atmosphere, training and improvement, effective interactions, needs assessment, quality of life, job dynamism, job satisfaction, delegation
17	Bjerregaard & Nielsen (2017)	Suitable working conditions, reward system, motivation, decentralization, management system, work–life balance, communication between supervisors and managers, welfare programs, organizational reputation and brand
18	Smith (2013)	Positive feelings about work, responsibility, productivity, job identity, independence and autonomy in the job, material and non-material rewards, participation, knowledge management, trust in elites
19	Dwomoh & Frempong (2017)	Rewards and compensation for services, financial benefits, supportive management system, work–life balance, organizational good image, reputation and credibility of the organization, suitable and desirable work environment, creating job security, meritocracy, establishing justice and fairness in the organizational structure, creating good relationships with managers and employees, constructive interactions with other organizations, creating value for the elite, supporting the ideas of the elite, promoting the position of the elite based on performance
20	Tumi et al. (2022)	Job enrichment, flexible structure, monetary and non-monetary rewards, attention to needs of elites and their family members, trust in elites, participation in training courses, relations with research centers, promotion of teamwork, support for the creativity and innovation of elites, salaries and fringe benefits, compensation for service
21	Scott et al. (2011)	Opportunity for learning and promotion, high pay, succession planning and delegation, granting more authority to elites, developing communication within the organization, establishing connections with the external environment, boundary spanning, flexible working hours, developing authority, organizational maturity
22	Sleiderink (2012)	Job independency, competitiveness, job development, job satisfaction, job rotation, appreciation, relationships with colleagues, working conditions, job security, promotion opportunities, salaries and fringe benefits, work–life balance, welfare programs, supportive management
23	King (2017)	Creating a supportive atmosphere, providing a path, a suitable work environment, organizational learning, supporting elites, creating organizational identity, evaluation, organizational culture, developing elite retention strategies, flexible working hours, leadership style and management system, salaries and fringe benefits, communication with managers

Stage 5: Extracting information from texts

The metasynthesis method aims to achieve an integrated and new interpretation of the findings. In this step, during the analysis, the researcher searches for themes that have emerged among the findings of the studies under study and, after identifying the themes, forms a classification and finally places related and similar categories in a topic that best describes those classified themes so that these topics are the basis for developing models and theories. This process is known as "thematic review" (Sandelowski and Barroso, 2006). In this research, first, all the factors identified in the studies in question are classified into similar categories, and then the main concepts are formed.

Stage 6: Quality control

The research team members always tried to review and re-code the extracted data in the steps of analyzing the identified factors. However, to ensure the validity of the research results, experts were asked to give their opinions on the accuracy, validity, and importance of selecting sources and the extracted results and do the scoring based on the critical appraisal skills program (CASP)

checklist. Fortunately, the sources were approved by the experts with a quantitative index of over 30 (Appendix 1). Also, to calculate the reliability of the data, the Cohen's kappa coefficient was used. For this purpose, an expert coded the concepts, and then the concepts presented by the researcher were compared with the concepts presented by the expert, and finally the kappa coefficient value was calculated at 0.617, which is at the valid level of agreement (Gwet, 2014).

Stage 7: Presenting findings

According to the analysis of qualitative findings of 23 final studies, 304 primary codes were identified. After several reviews and revisions, the newly identified codes were summarized into 20 sub-concepts, and these sub-concepts were categorized into 10 main concepts (Table 2).

Table 2.

Codes and concepts of elite retention in organizations

Main concept	Sub-concept	Open codes
Training & improvement	Knowledge enhancement	Providing conditions for elites to participate in training courses
		Providing study opportunities for elites
		Organizing training courses and workshops
		In-service training
	Organizational learning	Knowledge management
		Knowledge sharing
		Creating learning and promotion opportunities for elites
		Creating conditions for scientific activities
		Knowledge development
	Participation	Participating elites in organizational decisions
		Participating and establishing relationships with elites
		Creating conditions for knowledge sharing for elites
		Creating opportunities for elite participation in organizational affairs
		Developing elite participation in long-term and short-term goal setting for organizations
Organizational structure	Restructuring	Creating a flexible organizational structure
		Downsizing organizations
		Decentralization in the organizational structure
		Simple and broad organizational structure
		Reducing the organizational hierarchy and creating an organic structure
	Culture building	Eliminating complex bureaucracies
		Developing teamwork
		Creating a group atmosphere and increasing cooperation
		Attending to organizational culture in order to retain elites
Organizational vision	Setting goals	Proving conditions for progress and advancement of elites
		Determining the path of progress
		Foresight for organizations
		Alignment with organizational strategies
		Creating opportunities for professional and practical development of elites
	Strategic plans	Developing strategies for elite retention
		Strategic planning for elite retention
		Organizational visions and strategies for elite retention
		Transparent missions and visions of organizations

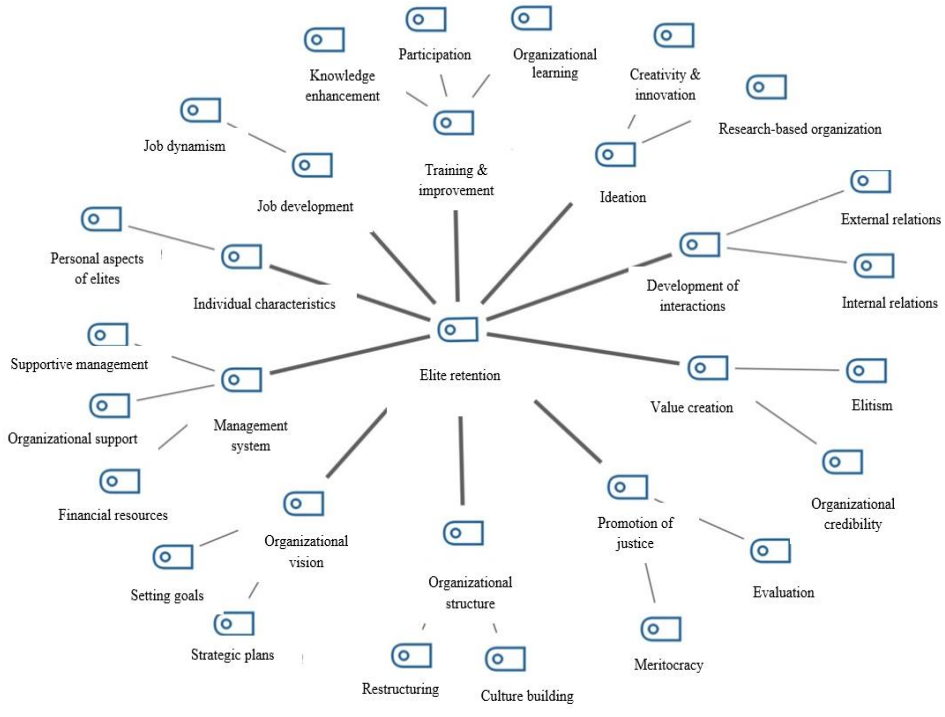
Main concept	Sub-concept	Open codes
Developing interactions	External relations	Establishing relations with the environment outside the organization
		Developing boundary spanning within the organization
		Developing interactions with other organizations
		Developing relationships with knowledge-based centers
		Establishing relations with research centers
	Internal relations	Creating opportunities for having relations with international scientific centers
		Developing relations within the organization
		Increasing relations between elites and managers
Job development	Job dynamism	Flexibility in working hours of the elite
		Enrichment of the elites' jobs
		Creating conditions for job rotation
		Creating the conditions of teleworking for the elite
		Promoting job independence
		Increasing job prestige
		Developing the role quality
		The challenging role of elites in organizations
Ideation	Creativity & innovation	Supporting the creativity and innovation of the elite
		Supporting the ideas of the elite
		Creating opportunities to present new ideas
		Commercializing the ideas of the elite
		Creating areas for growth and development of the elite
		Creating intellectual property for the elite
	Research-based organization	Creating research opportunities for the elite
		Supporting the scientific achievements of the elite
		Supporting the research of the elite
		Providing research credits for the elite
		A sense of dynamism in organizations
		Supporting the risk-taking of the elite
Value creation	Organizational credibility	Organization's good image
		Organization's reputation and credibility
		Organization's identity and brand
		Organization's international image
		Type and level of colleagues
	Elitism	Reward and recognition
		Responding to needs of the elite
		Promoting social welfare
		Supporting and honoring family members
		Succession planning
		Delegating authority to the elite
		Needs assessment of the elite
Promotion of justice	Evaluation	Promoting the position of the elite based on performance
		Trusting the elite and using them in organizational affairs
		Performance-based evaluation of the elite
		Establishing an effective evaluation system
		Justice-based evaluation
	Meritocracy	Establishing a system of distributive justice
		Developing transparency in organizations
		Promoting organizational justice
		Attending to talents and creating competitive opportunities
		Establishing justice and fairness in the organizational structure
Management system	Organizational support	Promoting freedom of action for the elite
		Developing job security for the elite
		Establishing a supportive management system
		Creating suitable working conditions for the elite
		Creating suitable physical working conditions for the elite
		Ensuring job security

Main concept	Sub-concept	Open codes
	Supportive management	Satisfaction with direct supervisors Talent acquisition Support of senior managers and upstream documents for elites and their plans Creating job opportunities Supporting the private sector Enacting supportive laws and policies Elite-oriented recruitment Elite recruitment Senior managers' support for elites Transparency in organizational regulations
	Financial resources	Promoting economic well-being Providing welfare facilities to the elite Availability of facilities and financial resources Work–life balance Development of the payment and compensation system Providing special facilities and privileges Rewards and compensation for the services of the elite
Individual characteristics	Personal dimension of the elite	Responsibility of the elite Professional commitment of the elite to their organizations Satisfaction of the elite Individual–organization fit Quality of life of the elite in various aspects Sense of belonging and permanence of the elite to their organizations

In the final step, after analyzing and categorizing the extracted codes, a conceptual model of the aspects affecting elite retention in organizations was provided with a comprehensive and holistic view.

Figure 2.

Conceptual model of elite retention in organizations



Discussion and Conclusions

Every organization requires strategies and micro and macro planning for its progress and development. The position and role of human resources in these strategies, as the major resources of organizations, are of great significance and prestige. Meanwhile, capable and elite human resources are regarded as one of the important and fundamental resources of organizations. Therefore, they need efficient and elite human resources to achieve their goals. Although managers cannot always prevent their valuable employees from leaving, they can greatly reduce the incidence of this decision by identifying and implementing effective policies and measures to retain them (Hosseinian & Shariati Jam, 2018). In this research, the aspects and components affecting elite retention in organizations were analyzed using the metasynthesis method and by reviewing the findings of qualitative research in domestic and foreign scientific databases. In this regard, 304 initial concepts were identified, which were categorized into 20 sub-concepts, and finally these sub-concepts were summarized into 10 main concepts (management system, organizational vision, organizational structure, development of interactions, ideation, training and improvement, value creation, job development, promotion of justice, and individual characteristics).

In today's competitive world, attracting and retaining elite talent is considered one of the most critical challenges faced by organizations. Management style is a key factor influencing the satisfaction, commitment, and retention of elite employees. Research findings indicate that management style is a crucial determinant in elite retention—an observation also supported by the studies of Zahedi and Eshraghi (2021) and Domo and Frimpong (2017). Organizations that adopt transformational, participative, and supportive leadership styles are generally more successful in retaining and nurturing top talent. Moreover, investing in the development of managerial leadership skills can serve as an effective strategy for sustaining a competent and capable workforce. At the same time, today's managers are increasingly required to enhance their strategic approaches and plan for the development of diverse capabilities across various organizational domains, including elite retention. They must effectively identify pressing and strategic issues and design efficient and appropriate management systems and programs to cope with emerging challenges (Faraji & Sarkhondi, 2017).

The findings of the research on the aspects affecting elite retention in organizations suggested that the management system plays a significant role in the retention of elites in organizations. As confirmation of these results, it can be stated that the management system in organizations is not a direct and linear activity, rather it includes skills that could be used to advance organizational goals. Through these skills, an organization would be developed and the desired goals would be achieved. Efficient management refers to performing tasks with minimal waste of resources and maximum optimal use of resources and opportunities so that the organization can maximize profits. An efficient manager is someone who uses limited resources to achieve the company's short-term and long-term goals. As a matter of fact, efficient management is a dynamic process taking the required measures to

achieve the goals of an organization. Instead of using the entire organization's capabilities to achieve short-term goals, effective management also thinks about long-term goals and, as a result, the stability and durability of the work system (Passarini et al., 2011). On the other hand, today's managers need to increasingly improve their strategic approach and plan various capabilities in different areas of their organizations, such as elite retention. They need to effectively identify pressing and strategic issues and design and develop appropriate and efficient management programs and systems to deal with difficulties (Faraji & Sarkhondi, 2017).

Developing organizational visions is one of the solutions to control the future that determines the destination of various organizations and coordinates the direction of all activities towards that destination. The organizational vision, by indicating the destination and orientation towards the outlined vision, is actually a guiding light for managers who are in search of new methods in the field of management (Nikdast, 2022). In point of fact, determining the organizational visions regarding elite retention in organizations determines the goals of all activities and group and individual efforts, and it plans the way those goals are achieved so that managers can identify what organizational structure they should use and what type of employees with what expertise to employ for each position and which style of leadership and supervision to use. Therefore, it can be said that organizational vision is actually the foundation of management, especially concerning elite retention in organizations. Furthermore, in the current competitive world, managers employ the tools of organizational restructuring and development to achieve goals, eliminate organizational inadequacies, increase productivity, change and adapt more to new activities, and use all expertise and abilities, retain elites, creatively organize with the aim of getting rid of prohibited or harmful activities, expand activities, focus on resource management, and separate the responsibilities of departments and individuals (Eriksson & Kjeang, 2021). It is worth noting that relationship management and development of interactions with employees and elites in an organization is a strategy for collecting their needs and business behaviors so as to lead to creating stronger relationships with them, as a strong relationship in this context is the most important secret to the success of any organization. The goal of employee relationship management is to empower the organization to provide better services to customers by introducing reliable automated processes for service, information collection and processing, and it tries to integrate and automate various customer service processes.

In this regard, one of the important tasks of managers in organizations is to identify the potential talents of employees and provide the foundations for their growth and prosperity by designing strategic plans and supportive management that provide the basis for attracting and retaining elites in the organization (Masoumi et al., 2023). In line with the above, the results of the research showed that indicators for determining the vision and developing the organizational structure for retaining elites are a very important strategic measure for the long-term success of any organization, which is consistent with the findings of the research of Nikmanesh et al. (2023), Arvand & Ghods

(2021), Zandi et al. (2019), and Tumi et al. (2022) in this field.

The research findings showed that the components of ideation and training play a prominent role in retaining elites in the organization. Elites often seek intellectual challenges and opportunities for creativity. Providing an environment for ideation makes them feel valued and their opinions influential. This sense of participation increases job satisfaction and, as a result, reduces the desire to leave the organization. When elites are involved in ideation processes, their sense of ownership over projects and the future of the organization is strengthened. This sense of belonging is a key factor in their long-term retention. Also, continuous training, especially training that is designed to suit the level and needs of elites, helps them grow in line with scientific and technical advances. This strengthens the sense of career advancement and increases the likelihood of them remaining in the organization, so that targeted training programs can identify and cultivate the managerial talents of elites. This growth path draws new horizons for them, which reduces the motivation to leave the organization and increases loyalty (Ranjbar and Darai-Manfared, 2017). Therefore, there is no doubt that by creating favorable conditions for ideation, training, and improvement, as well as developing organizational infrastructure in this regard, organizations can be very successful in retaining elites and increase their chances of retaining the organization's valuable and elite human capital several times over. The importance of these results has also been pointed out in the research findings of Moradi and Shokri (2022), Rezaian et al. (2018), Taghizadeh Yazdi et al. (2018), and Dwomoh & Frimpong (2017).

The research findings showed that the components of value creation, attention to individual characteristics, and promotion of justice in the organization have a major impact on retaining elites in the organization, which is consistent with the findings of Zahedi & Eshraghi (2021), Shateri et al. (2015), King (2017), and Scott et al. (2011). Regarding these results, it can be explained that in order to provide desirable and acceptable behavior in line with the organization's goals, human resources should be both motivated and feel valued in the organization. This is achieved by identifying behavioral reasons or causes of desire and reasons for employees' motivation and satisfaction so as to direct their behavior towards achieving organizational goals and in order for them to be employed by competent and competent managers in a timely manner with the aim of creating a desirable and appropriate work environment (Jahangiri, 2021). Therefore, valuable and elite human resources are the most significant competitive advantage and the main factor in the success of organizations. In this regard, organizations need organizational advantages to achieve competitive advantage and retain elites in the organization, one of which is focusing on elite human resources and creating value for them (Sanchez et al., 2019). On the other hand, paying attention to individuals' personality aspects, especially in the organization's elites, is one of the issues that can help organizations achieve productivity. Personality is a set of emotional and behavioral traits surrounding and accompanying an individual in their daily life. One of the main and fundamental topics of psychology is unquestionably personality

traits. Since these traits form the basis of individuals' behavioral systems, addressing this topic can shed light on specific aspects of individuals' performance in various fields, such as increasing commitment and retention in organizations. Additionally, a clear example of this is the effect of individuals' personality traits on their job performance in organizations (Oladi et al., 2018).

Elite and efficient human resources play a vital role in various national fields. Human resources are the most important organizational capital; therefore, desirable management is considered very important in order to retain elites in organizations. The management of elite and talented human resources represents a paradigm shift from traditional human resource management to modern human resource management that includes special attention to organizational elites. Thus, it is proposed:

1. Developing and institutionalizing a comprehensive system for retaining and maintaining elites in organizations
2. Networking and creating institutions to establish relationships with elites in organizations
3. Establishing a meritocracy system in various fields for elites
4. Participating elites in the organization's staff affairs in order to strengthen a sense of commitment and responsibility
5. Creating financial support and welfare and economic facilities for elites in organizations
6. Mapping a path of progress for organizations' elites
7. Creating areas for knowledge sharing for elites in organizations

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RESEARCH ARTICLE **Open Access**

Application of Clustering and Classification Algorithms in Analyzing Customer Behavior in Data-Driven Marketing: A Case Study of Amazon Customers

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Abstract
In data-driven marketing, customer behavior analysis plays a crucial role in developing targeted marketing strategies aimed at increasing return on investment, enhancing profitability, and gaining a larger market share. In this study, four clustering methods- including K-means, density-based clustering, principal component analysis, and hierarchical clustering- as well as four classification methods- including Support Vector Machine, XGBoost, Random Forest, and Gradient Boosting- are examined for customer behavior analysis. The data for this study was extracted from the "Amazon Customer Behavior Survey" dataset, which includes 23 features from 602 customers. Initially, the data was preprocessed, and then, using clustering methods, customers were divided into different groups. The performance of these methods was evaluated based on criteria such as the silhouette index, and ultimately, appropriate marketing strategies for each cluster were proposed. Additionally, to examine the possibility of predicting customer membership in the extracted clusters, the aforementioned classification models were implemented and compared. The results indicate that the K-means method performed the best in clustering, while the XGBoost model performed the best in classification. The innovation of this research lies in combining clustering and classification methods to provide targeted marketing strategies and comprehensively comparing these methods on real customer data. This study demonstrates that combining clustering and classification methods can help businesses better understand customer behavior and make more optimal marketing decisions
Keywords: *Data-Driven Marketing, Machine Learning, Customer Clustering, K-Means Clustering, Customer Classification*

Introduction

In today's highly competitive business environment, understanding customer behavior is crucial for improving profitability and fostering customer loyalty. With rapid technological advancements and the growing volume of data being generated across industries, data-driven marketing has become an integral aspect of decision-making for organizations. By utilizing analytical methods to cluster and classify customers, businesses can create targeted marketing strategies and enhance customer experiences (Woos et al., 2021).

Leveraging machine learning techniques to analyze customer behavior allows organizations to uncover hidden patterns in customer data, leading to better-informed

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decisions. Clustering and classification are two core techniques in this context: clustering groups customers based on behavioral similarities, while classification predicts future customer behavior using historical data. Both methods offer unique advantages and challenges, and choosing the appropriate technique can significantly impact the success of marketing initiatives (Alioumeni et al., 2024).

This study explores four clustering methods—K-Means, Density-Based Clustering, Principal Component Analysis (PCA), and Hierarchical Clustering—along with four classification methods—Support Vector Machine (SVM), XGBoost, Random Forest, and Gradient Boosting—in analyzing Amazon customer behavior. Using data from Amazon's customer behavior survey, which includes 602 customers and 23 features, clustering techniques segment customers into distinct groups. The effectiveness of these techniques is assessed using the silhouette index. Subsequently, classification models predict customer membership within the clusters, and their performance is evaluated using appropriate metrics.

The novelty of this research lies in its integration of both clustering and classification methods to devise targeted marketing strategies, providing a comprehensive comparison of these techniques applied to real-world customer data. Unlike previous studies that primarily focus on either clustering or classification, this research combines both approaches to offer a more holistic view of customer behavior. The results are expected to help businesses personalize marketing efforts, improve customer experiences, and boost customer loyalty (Dust Mohammadi, 2014).

This article is structured as follows: the problem statement section discusses the significance of customer behavior analysis and the challenges involved. The theoretical foundations section defines key concepts related to clustering, classification, and model evaluation metrics. The literature review highlights relevant studies in this field. The methodology section details the data, techniques, and experimental setup. The research findings section presents the results of the various analytical methods and their comparative analysis. Finally, the discussion and conclusion section interprets the results, explores their practical implications, and provides recommendations for future research to enhance marketing strategies (Ahmadipanah, 2022).

Customer behavior analysis, as a crucial component of data-driven marketing, plays a pivotal role in improving strategic decision-making, optimizing resource allocation, and enhancing customer experiences. Such analyses offer valuable insights into customer needs, preferences, and behavioral patterns, enabling businesses to implement more targeted and personalized marketing strategies. The application of advanced data mining and machine learning techniques in customer behavior analysis is expanding, allowing businesses to extract meaningful patterns from complex and diverse datasets, thereby improving customer satisfaction and developing effective marketing strategies (Guirla Navarro et al., 2021).

Data-driven marketing involves using customer data to inform marketing decisions and create effective strategies. This approach enables businesses to tailor messages, offers, and customer experiences based on reliable data, rather than assumptions. The goal of data-driven marketing is to collect and

analyze various customer data points—such as purchase behavior, online interactions, search history, and preferences—and input these into advanced algorithms to uncover hidden patterns and relationships. This empowers businesses to create more accurate and data-supported marketing campaigns (Guirla Navarro et al., 2024).

Data mining encompasses various analytical methods aimed at uncovering patterns and insights from large, complex datasets. It equips businesses with tools to derive meaningful information about customer behavior, preferences, and sales processes. Techniques such as clustering, classification, and regression are commonly used in data mining (Tabianan et al., 2024).

Machine learning, a subset of data mining, focuses on developing algorithms that enable systems to learn from data and predict future behaviors. In customer behavior analysis, machine learning is particularly useful for clustering, classification, and forecasting future customer actions. These techniques allow businesses to group customers based on similar characteristics or predict future group memberships with high accuracy.

Customer clustering is one of the most widely used methods in behavior analysis, grouping customers into similar categories based on shared characteristics. Clustering, an unsupervised learning method, helps businesses segment customers based on behavioral similarities or preferences, facilitating the development of tailored marketing strategies. Key clustering algorithms include K-means, density-based clustering, PCA, and hierarchical clustering.

K-means is one of the simplest and most commonly used clustering methods, dividing data into K clusters based on Euclidean distance. While effective due to its simplicity and computational speed, K-means may struggle with complex or non-linear data structures.

Density-based clustering, however, is ideal for complex datasets with unclear boundaries. It groups data points based on density, effectively identifying clusters and distinguishing noise from valuable data.

PCA is often employed for dimensionality reduction, but it also serves as a preprocessing step for clustering. By reducing data dimensions, PCA highlights significant features, improving clustering results.

Hierarchical clustering creates clusters in a hierarchical structure, which is useful for modeling complex relationships among data points, especially in datasets with inherent hierarchical properties (Nilashi et al., 2021).

Classification, another important machine learning technique, predicts the label or category of each data instance. This study uses several classification algorithms, including SVM, XGBoost, Random Forest, and Gradient Boosting, all of which are highly effective in predicting customer attributes or behaviors.

SVM is a robust classification method that uses decision boundaries to differentiate between classes, especially in high-dimensional or non-linear data.

XGBoost utilizes decision trees for classification and incorporates gradient boosting to improve prediction accuracy. It has gained recognition as one of the best classification models, excelling in numerous data science competitions.

Random Forest combines multiple decision trees, improving prediction accuracy by using random feature selection to handle complex and noisy data.

Finally, Gradient Boosting, similar to XGBoost, builds trees sequentially, with each new tree correcting errors made by the previous one. It is particularly well-suited for large, complex datasets (Li et al., 2021).

Literature Review

Sharifi Esfahani et al. (2023) conducted a study titled " Providing an approach based on customer purchase history and product recommendations to customers: A case study of Digikala customers. The study aimed to recommend products to customers who had previously made purchases from Digikala and addressed key questions such as: How can Digikala's customers be segmented? How many customer groups can be identified based on their purchase history? And what are the product recommendation strategies for each customer group? The research employed a hybrid approach combining the transactional model for identifying loyal customers and the K-means clustering algorithm. The findings revealed that the pricing strategy for loyal customers (Cluster 0) suggested higher-priced products compared to other clusters. To encourage these customers to purchase high-value products, special discount strategies were proposed, enhancing customer engagement in product search and selection (Sharifi Esfahani et al., 2023).

Dadras et al. (2023) investigated the impact of customer segmentation on financial marketing in the National Bank of Iran in their paper “A study of the financial marketing model of the National Bank of Iran with emphasis on customer grouping, financial engineering, and securities management.". This study was mixed-method and applied-developmental research, conducted using a descriptive-survey method. The target population consisted of bank employees and marketing experts, with 385 participants selected via Cochran’s formula. Data were collected through questionnaires and analyzed using SPSS and PLS software for structural equation modeling. The findings identified six main components in the bank's financial marketing model: causal conditions, intervening conditions, core categories, strategies, consequences, and contextual conditions. The study confirmed the significant impact of causal conditions (51.673), contextual conditions (41.965), and intervening conditions (40.074) on financial marketing, supporting all proposed hypotheses (Dadras et al., 2023).

Mohaghegh et al. (2023) examined the influence of modern banking trends and financial technologies on customer behavior and competition in the banking industry in their study “Explaining the financial marketing model with emphasis on customer segmentation of Tejarat Bank Iran.". This qualitative, applied-developmental research was conducted using a descriptive survey approach. The target population included managers and experts from Bank Tejarat and university professors in marketing and financial management in Tehran. The sample was selected using the snowball sampling method, and theoretical saturation was reached after 15 interviews. Data were collected through semi-structured interviews and analyzed using coding and grounded theory methods. The results confirmed the financial marketing model of Bank Tejarat, consisting of six primary dimensions, and provided practical recommendations based on the findings (Mohaghegh et al., 2023).

Safabakhsh and Asayesh (2022) conducted a study to segment banking customers based

on customer lifetime value and profitability potential in their study Segmentation of bank customers based on customer lifetime value and their profitability ability (case study: customers of a private bank). They analyzed the savings accounts of Karafarin Bank over a period from 2016 to 2019, using clustering methods and parameters such as retention rate, churn rate, inflation, and average balance. The study classified customers into six segments, from premium to least valuable customers. The innovation of this study lies in the application of customer lifetime value for banking market segmentation, enabling bank managers to identify profitable customers and tailor marketing strategies accordingly (Safabakhsh et al., 2022).

Bahrainizad, Assar, and Esmailpour (2022) Segmenting online retail customers based on demographic characteristics and customer experience. This study, conducted on 384 online customers, identified three distinct customer segments: frequent buyers, who highly value their interaction with sellers; utilitarian buyers, who prioritize trust and perceived benefits; and visual buyers, who purchase less frequently and focus on product presentation and familiarity with the store. The findings contribute to refining marketing strategies and enhancing online shopping experiences (Bahrainizad et al., 2022).

Taghavi Fard et al. (2022), in a study titled "Esmaeilpour 2022 Survey-based, Clustering. Customers were segmented into three groups.Customer clustering in the field of electronic banking using electronic transactions and demographic information (case study: Refah Bank)", aimed to identify and classify customers in the domain of electronic banking. This applied research used K-means clustering and included steps such as data collection, preprocessing, clustering, and interpretation of results. The study segmented customers into five clusters: (1) young customers (20–30 years old) with high education levels who primarily use mobile banking; (2) middle-aged customers (30–45 years old) with medium education levels who prefer PC-based banking; (3) elderly customers (45+ years old) with low education levels who rely on ATMs; (4) female customers who frequently use bill payments and mobile top-up services; and (5) male customers who mainly use fund transfers and electronic checks. Based on these findings, the authors proposed tailored banking services for each segment. The study highlighted the effectiveness of K-means clustering in customer segmentation within electronic banking and provided practical recommendations for improving service delivery (Taghavi Fard et al., 2022).

Abouei Mehrizi et al. (2020) applied data mining techniques to analyze customer purchase behavior in a retail store. Their research aimed to extract knowledge from shopping basket data to better understand customer purchasing patterns and offer targeted marketing recommendations. This applied study involved data collection, preprocessing, and knowledge extraction. Customers were clustered into five groups based on their purchase habits, including essential goods buyers, processed food buyers, hygiene product buyers, and others. The study provided valuable insights for targeted marketing strategies in retail environments (Abouei Mehrizi et al., 2020).

Nur Kamisa, Almira Duita P., and Dian Novita, in their 2022 study titled "The influence of online customer reviews and online customer ratings on customer trust" examined the impact of online customer

reviews and ratings on consumer trust in online shopping on the Shopee platform. This study employed a quantitative method, analyzing a sample of 100 individuals who had made at least three purchases on Shopee. Data were collected through questionnaires, and path analysis was conducted using SPSS version 16 to analyze the results. The findings indicated that online customer reviews and ratings positively and significantly influenced consumer trust in the Shopee platform (Nur Kamisa et al., 2022).

Dr. Homa Loon and Dr. Prajakta Warale, in their 2022 paper titled " Cluster Analysis: Application of K-Means and Agglomerative Clustering for Customer Segmentation" explored customer segmentation and the use of clustering techniques to create clusters of similar customers. This research was conducted on a dataset of 200 customers, utilizing K-Means and other clustering algorithms to identify customer groups. The objective of this study was to create clusters of customers with similar characteristics, which can be useful in applications such as targeted marketing and industry analysis. Various machine-learning libraries in Python were used for this analysis. The results were visualized using the elbow method and dendrogram analysis to evaluate the clustering performance (Hema Loon et al., 2022).

Alamshah, P. Eko Prasetyo, Sonyoto, Siti Hernina Bintari, Danang Dwi Saputro, Shuhei Hator Rohman, and Rizka Nur Pratama, in their 2022 paper titled "Customer Segmentation Using the Integration of the Recency Frequency Monetary Model and the K-Means Cluster Algorithm" analyzed customer segmentation in retail companies using the Recency-Frequency-Monetary (RFM) model and the K-Means clustering algorithm. The objective of this study was to segment customers using the RFM model and the K-Means algorithm, optimized through the elbow method. This research employed various approaches, with the RFM model selected as an optimal method for customer segmentation, and the K-Means algorithm chosen for its interpretability, fast convergence, and adaptability. To address the weaknesses of K-Means and determine the optimal number of clusters (k), the elbow method was applied. The study found that three customer clusters were identified with an optimal Sum of Squared Errors (SSE) value of 25,829.39 and a Calinski-Harabasz Index (CHI) of 36,625.89. These findings suggest that integrating the RFM model with the optimized K-Means algorithm can serve as an effective customer segmentation method (Alamshah et al., 2022).

Denny Pratama Putra, Lia Supriharini, and Rony Kurniawan, in their 2021 paper titled "Celebrity Endorser, Online Customer Review, and Online Customer Rating on Purchasing Decision with Trust as an Intervening Variable on Tokopedia Marketplace" examined the impact of celebrity endorsers, online customer reviews, and online customer ratings on purchase decisions, considering trust as a mediating variable. The objective of this study was to determine the direct and indirect effects of these factors on consumer purchasing behavior on the Tokopedia platform. A sample of 100 users was randomly selected, and data were analyzed using descriptive tests, data quality tests, classical assumption tests, path analysis, and hypothesis testing. The findings revealed that celebrity endorsers, online customer reviews, and online customer ratings significantly influenced purchase decisions. Additionally,

trust had a significant effect on purchase decisions but did not mediate the relationship between the identified factors and purchase intent. Based on the results, the researchers suggested that Tokopedia should continue to strengthen influential factors such as celebrity endorsers, online customer reviews, and ratings to enhance purchase decisions (Denny Pratama Putra et al., 2021).

Halilah Tien Harianto and Lantap Trisnarnno, in their 2020 paper titled "Analysis of the Influence of Online Customer Reviews, Online Customer Ratings, and Star Sellers on Customer Trust and Purchasing Decisions in Online Stores on Shopee" analyzed the impact of online customer reviews, online customer ratings, and the star-rated seller feature on customer trust and its influence on purchase decisions on the Shopee online shopping platform. The objective of this study was to identify models, hypotheses, and features that could influence customer trust and purchase decisions. This research utilized Structural Equation Modeling (SEM) with Partial Least Squares (PLS) and surveyed 100 respondents. The results indicated that online customer reviews, online customer ratings, and the star-rated seller feature had a positive and significant effect on customer trust, with online customer reviews having the highest impact. Additionally, customer trust had a positive and significant effect on purchase intention, while purchase intention and social influence positively and significantly impacted purchase decisions. However, unexpected circumstances did not significantly affect purchase decisions (Halilah Tien Harianto et al., 2020).

Budoyono, Muhammad Twain, Dewi Mulyasari, and Serly Andini Resto Putri, in their 2020 paper titled "An Analysis of Customer Satisfaction Levels in Islamic Banks Based on Marketing Mix as a Measurement Tool" examined customer satisfaction levels in Islamic banks using the marketing mix as a measurement tool. The objective of this study was to determine customer satisfaction levels and prioritize customer segmentation in BNI Syariah Bank in Surakarta based on the marketing mix while analyzing the differences between perceived satisfaction and importance among priority customers. This study was quantitative and descriptive, with a population of 352 priority customers at BNI Syariah Bank in Surakarta. A simple random sampling method was employed, with a sample size of 78. Data analysis was conducted using Importance-Performance Analysis (IPA), where variables were measured on an ordinal scale. The results showed that customers were satisfied with the marketing mix attributes, including product, place, promotion, people, processes, and physical evidence, at BNI Syariah Bank in Surakarta. However, customers were dissatisfied with the price attribute, as Islamic banks were generally perceived as more expensive than traditional banks. Additionally, no significant difference was found between customer satisfaction levels and perceived importance among priority customers based on customer segmentation (Budoyono et al., 2020)

Table 1.
Literature review

Title	Author	Year	Methods	Results
Providing an approach based on customer purchase history and product recommendations to customers: A case study of Digikala customers	Esfahani, et al.	2023	K-Means, RFM	Loyal customers respond better to recommendations.
A study of the financial marketing model of the National Bank of Iran with emphasis on customer grouping, financial engineering, and securities management.	Dadras, et al.	2023	SEM	The financial marketing model was designed with six key dimensions
Explaining the financial marketing model with emphasis on customer segmentation of Tejarat Bank Iran.	Mohaghegh, et al.	2023	Data analyze	A six-dimensional marketing model was designed
Segmentation of bank customers based on customer lifetime value and their profitability ability (case study: customers of a private bank)	Safabakhsh & Asayesh	2022	clustering techniques	Customers were segmented into **six groups**
Segmenting online retail customers based on demographic characteristics and customer experience	Bahrinizad, Asar & Esmaeilpour	2022	Survey-based, Clustering	Customers were segmented into **three groups**
Customer clustering in the field of electronic banking using electronic transactions and demographic information (case study: Refah Bank)	Taghavi Fard, et al.	2022	R+FMW, RFM	The R+FMW model outperforms the base RFM model in accuracy.
Analyzing customer purchasing behavior in a retail store using data mining. International Conference on Industrial Engineering	Aboei Mehryzi et al.	2020	A business analysis approach	The findings support decision-making in marketing, store layout optimization, and product recommendations to customers. The approach was applied to data from the Hazarmart Hypermarket in Mehriz, and results were validated using error sums and expert opinions.
The influence of online customer reviews and online customer ratings on customer trust	Noor Kamisa et al.	2022	data analysis	The study found that online customer reviews and online customer ratings have a positive and significant effect on consumer trust in the Shopee Marketplace.
Cluster Analysis: Application of K-Means and	Dr. Homa Loon et al.	2022	K-means, machine learning	The application of K-means and Agglomerative clustering successfully created customer

Title	Author	Year	Methods	Results
Agglomerative Clustering for Customer Segmentation				clusters based on their similarities, helping to understand customer groupings for targeted business applications.
Customer Segmentation Using the Integration of the Recency Frequency Monetary Model and the K-Means Cluster Algorithm	Alamshah, P. Eko Prasetyo et al.	2022	RFM, K-Means	The study identified three customer segments with an optimal Sum of Square Error value of 25,829.39 and a Callinski-Harabaz Index value of 36,625.89, indicating these as the best clustering results.
Celebrity Endorser, Online Customer Review, Online Customer Rating on Purchasing Decision with Trust as an Intervening Variable on Tokopedia Marketplace	Denny Pratama Putra et al.	2021	data analyze	Celebrity Endorser, Online Customer Review, and Online Customer Rating significantly influence Purchase Decision. Trust affects Purchase Decision, but it does not mediate the relationships.
Analysis of the Influence of Online Customer Reviews, Online Customer Ratings, and Star Sellers on Customer Trust and Purchasing Decisions in Online Stores on Shopee	Halila Tin Hariyanto et al.	2020	PLS, SEM	Customer review, customer rating, and star seller significantly and positively affect customer trust, with customer reviews having the most dominant influence. Trust positively affects purchase intention, which in turn influences the final purchase decision. Unexpected situational factors do not affect the decision.
An Analysis of Customer Satisfaction Levels in Islamic Banks Based on Marketing Mix as a Measurement Tool	Budiyono et al.	2020	data analyze	Customers are satisfied with most marketing mix attributes, people, process, physical evidence) but are dissatisfied with the price attribute, as Islamic banks are perceived as more expensive than conventional banks. There is no significant difference between satisfaction and importance levels based on customer categories.

Methodology

This research aims to compare different clustering and classification methods in analyzing customer behavior at Amazon. To this end, survey data on Amazon customers' behavior, comprising 23 features from 602 customers, have been utilized. These data were analyzed to identify behavioral patterns and categorize customers into distinct groups. The research follows a quantitative, data-driven approach, leveraging machine learning techniques for data processing and analysis.

The dataset used in this study is derived from Amazon customer behavior records. This dataset includes various features such as demographic information, purchase history, customer preferences, and engagement levels with the brand. Prior to model implementation, data preprocessing was conducted, including the removal of outliers, normalization of numerical features, imputation of missing values, and conversion of categorical variables into numerical representations.

The selected dataset contains behavioral information on customers' purchases and interactions with Amazon. It encompasses variables such as customer age, income, frequency of Amazon usage, satisfaction levels, types of purchased products, and repeat purchase rates. Regarding data quality, no missing values were present in this dataset, ensuring the accuracy of analyses. The absence of missing values eliminates the need for imputation methods, allowing for direct and high-quality data analysis.

Additionally, correlation coefficients were calculated to measure the relationships between different variables. For instance, income and repeat purchase rate showed a correlation coefficient of 0.65, while age and service satisfaction exhibited a correlation coefficient of 0.52. These positive correlations indicate that higher-income customers tend to make more repeat purchases and express higher satisfaction with services. Descriptive statistical analysis revealed that the mean customer age is 35.2 years, the mean monthly income is $4,500, and the mean repeat purchase rate is 3.4 times per month. The median values for these variables are 34 years, $4,300, and 3 times per month, respectively. The highest frequency of customers falls within the age range of 30 to 40 years, and customers with an income between $3,000 and $5,000 exhibit the most frequent repeat purchases. Moreover, the income variance is $15,000, and the standard deviation of customer satisfaction is 0.8. The age distribution shows slight negative skewness, indicating a smaller proportion of older customers, while the income distribution exhibits positive kurtosis, signifying a concentration of customers with moderate to high incomes. The combination of the absence of missing values, high correlation coefficients between key variables, and extensive descriptive statistics ensures a thorough and precise analysis of Amazon customer behavior.

For clustering customers based on purchasing behavior and other relevant attributes, four clustering methods were examined and compared: K-Means, hierarchical clustering, principal component analysis (PCA), and density-based clustering. These methods were implemented using the Elbow method to determine optimal cluster numbers, with silhouette scores used to evaluate clustering quality.

In the K-Means method, data points are initially assigned to a predefined number of clusters. The algorithm randomly selects initial cluster centers and assigns data points to the nearest center. Then, the mean of each cluster is computed, and cluster centers are updated iteratively until convergence is reached. Although K-Means is widely used due to its efficiency and simplicity, its performance is highly sensitive to the initial number of clusters and may not be effective for complex data distributions.

To determine the optimal number of clusters, the Elbow method was employed. This approach evaluates within-cluster sum of squares (WCSS) for different cluster counts, identifying the point where further increases in clusters result in diminishing improvements. Based on the Elbow method, four clusters were determined as the optimal number for this dataset, indicating distinct customer segments based on purchasing behavior.

In contrast, hierarchical clustering organizes data into a tree-like structure using either agglomerative or divisive approaches. In the agglomerative approach, each data point starts as an individual cluster, and

clusters are merged iteratively based on similarity until all data points form a single cluster. In the divisive approach, all data points start in one cluster and are progressively split into smaller clusters. This method does not require prior specification of the number of clusters and is suitable for hierarchical data structures; however, its computational complexity makes it inefficient for large datasets.

Although PCA is not a direct clustering method, it serves as a dimensionality reduction technique that enhances clustering performance by reducing the number of features while preserving critical data variance. PCA computes the covariance matrix of feature variables and extracts principal components that capture the highest variance, improving computational efficiency for subsequent clustering algorithms.

Density-based clustering, on the other hand, groups customers based on point density. In this approach, high-density regions are identified as clusters, while low-density regions are classified as noise or outliers. Unlike K-Means, density-based clustering effectively detects clusters of arbitrary shapes and is robust to noise; however, it is sensitive to parameter selection.

Following customer clustering, classification methods were employed to predict customer membership in specific clusters. Four classification techniques were evaluated: Support Vector Machine (SVM), Random Forest, Gradient Boosting, and XGBoost. These models were implemented and assessed using relevant performance metrics.

SVM constructs an optimal decision boundary to separate data points. It maps data into a high-dimensional space and determines a hyperplane that maximizes the margin between classes. If data are not linearly separable, kernel functions are used to transform them into a higher-dimensional space for improved classification performance. While SVM is effective for complex datasets with nonlinear relationships, its computational cost increases with larger datasets.

Random Forest utilizes multiple decision trees to predict customer groups. Each tree is trained on a subset of the data, and final predictions are determined via majority voting. This method provides high accuracy and robustness against overfitting; however, due to the ensemble of multiple trees, interpreting results can be challenging.

Gradient Boosting builds a series of weak models iteratively, correcting previous errors in each step to minimize prediction error. While this approach achieves high classification accuracy, it is computationally expensive.

XGBoost, an optimized version of Gradient Boosting, enhances computational speed and performance by incorporating parallel processing and regularization techniques to prevent overfitting. Due to its efficiency and high predictive power, XGBoost is widely used in academic and industrial applications.

Comparing these classification methods based on multiple evaluation metrics can provide valuable insights into selecting the most effective algorithm for customer behavior analysis and marketing strategy optimization.

The clustering output shows that K-means clustering groups customers based on purchase satisfaction and frequency of visits. The chart illustrates different clusters along

with their mean centers, which are displayed in different colors. Analyzing each cluster reveals the following:

• **Cluster 1:** Includes users who browse several times a week and have average satisfaction. These users likely need more browsing, but they are not satisfied enough with their purchase or product to increase their satisfaction.

• **Cluster 2:** Users who browse multiple times a day and have high satisfaction. This group likely includes loyal customers or users who are very satisfied with their purchases and are actively seeking new products or deals. They may be ideal targets for marketing and loyalty programs.

• **Cluster 3:** Users who browse several times a week and have high satisfaction. These users are somewhat active and satisfied with their purchases, and they are likely to continue buying regularly.

• **Cluster 4:** Users who browse several times a week but have average satisfaction. These customers may need improvements in their shopping experience or after-sales service to increase their satisfaction.

As a result, customers who browse several times a week generally show either moderate or high satisfaction, indicating that increasing browsing frequency is associated with higher satisfaction levels. However, users with moderate satisfaction may need support or improvements in their experience to increase their satisfaction.

The K-means algorithm is widely used due to its simplicity, speed, and efficiency in processing different types of data. This algorithm works well for numerical and categorical variables (such as purchase satisfaction and visit frequency). However, it has limitations when dealing with non-spherical data or outliers. Nevertheless, with proper data preprocessing, K-means remains a powerful tool for customer segmentation and data analysis.

In further experiments with different clustering methods on the selected dataset, including density-based clustering, analyzing customer behavior in each cluster indicates that, since the dataset includes purchase satisfaction and visit frequency, these two features can form the basis for classifying customer behavior and developing marketing strategies. Based on this information, customers can be categorized, and appropriate strategies can be proposed for each category.

• Users with high purchase satisfaction and high visit frequency: These users are likely loyal customers who enjoy browsing the site and are satisfied with their purchases. Marketing strategies for this cluster could include loyalty programs, personalized product recommendations, and quick updates about new products.

• Users with average purchase satisfaction and average visit frequency: These users visit the site occasionally but have not yet been fully convinced to buy from a specific brand or product. Marketing strategies for this group might include targeted discounts, special offers, or additional incentives to increase their satisfaction and engagement with the brand.

In hierarchical clustering, the structure of this method allows flexible decision-making regarding the number of clusters, where various cuts can be made along the dendrogram to reveal different levels of detail. For example, in a typical customer segmentation, hierarchical clustering may reveal several distinct customer groups:

• **High-value customers:** A cluster of loyal customers who make frequent purchases and respond positively to promotional offers.
• **Occasional buyers:** A segment of customers who make few and infrequent purchases, often influenced by seasonal promotions or special events.
• **At-risk customers:** A group of customers whose buying behavior has decreased over time, indicating a potential risk of customer churn.
• **Low-value or inactive customers:** A segment of customers who rarely make purchases and have minimal engagement with the brand.

Hierarchical clustering helps businesses observe relationships between customers and uncover hidden patterns that may not be revealed through traditional analysis. Additionally, businesses can adjust the similarity threshold to examine broader or more precise segmentations based on their strategic needs.

Despite the advantages of this method, hierarchical clustering also faces challenges. It is computationally more intensive than some other clustering methods, and as the dataset size increases, the process can become slower. Furthermore, hierarchical clustering is sensitive to the distance metric and linkage method, meaning small changes in these settings can result in significantly different clusters. It is also sensitive to noise in the data, and small variations in the data may lead to major changes in the resulting clusters.

In principal component-based clustering, which reveals potential patterns or clusters in the data, the results indicate that points are scattered across the graph, but in some areas, the concentration of points is higher. These concentrations might represent natural clusters in the data. Areas with higher point density could indicate customers with similar behaviors. Several regions of point density are visible, which may suggest potential clusters.

The results of principal component-based clustering for the "purchase satisfaction" and "search frequency" features in the selected dataset indicate that these form four potential clusters:

• Cluster 1: High satisfaction and high search frequency: This group represents loyal customers who enjoy their purchase experience and regularly visit the website to explore new products. The best marketing strategy for this group would focus on loyalty programs and special offers. Offering discounts, loyalty points for repeat purchases, and regular updates about new products could encourage these customers to continue shopping. Personalized offers based on browsing and purchase history could also increase engagement and strengthen their loyalty.
• Cluster 2: High satisfaction and low search frequency: This group has high satisfaction but low search frequency, indicating that they may be less active in searching for products online. To engage these customers and increase their interaction, email campaigns introducing new products or seasonal discounts could be effective. Offering time-limited discount codes or alerts about special sales could encourage these customers to return to the website and browse more products.
• **Cluster 3:** Low satisfaction and low search frequency: This group consists of customers who are dissatisfied with their purchases and rarely visit the website. This group may have had a negative shopping experience or shown little interest in the products. The strategy

here should focus on improving the user experience and providing customer-centric services. Conducting short and clear surveys to understand their issues and offering initial discounts or better services could encourage these customers to reconsider and re-engage with the brand.

• **Cluster 4:** High search frequency and low satisfaction: This group browses the site frequently but is dissatisfied with their shopping experience, likely due to high prices, poor product quality, or insufficient customer support. The appropriate strategy for this group could involve improving transparency and providing more detailed information about products. Offering special deals, and guarantees, and showing reviews from other customers could help build trust. Educational content or product guides could assist customers in making better purchasing decisions.

Using principal component-based clustering for a dataset that includes various customer behavior features offers several valuable benefits. Due to the complexity and diversity of the data, features like satisfaction and search frequency may have correlations that make precise analysis challenging. Principal component-based clustering can transform these correlated features into independent principal components, preserving essential information and eliminating unnecessary dimensions and correlations. This dimensionality reduction makes the data more compact and less noisy, ultimately leading to more accurate clustering.

Another advantage of principal component-based clustering in this dataset is a significant improvement in the visual interpretation of customer clusters. By reducing the data to two principal components, the data can be displayed in a two-dimensional space, making it easier to identify different customer groups and their behavioral patterns. This visual representation of clusters is useful for analysts and marketing teams, as they can quickly identify groups of customers with similar behaviors and better understand the differences between these groups.

Overall, using principal component-based clustering for this dataset helped manage the inherent complexities of customer data and performed clustering more efficiently and interpretably. This clustering also contributes to better marketing strategies and enables targeted services and offers for customers.

In this study, K-means clustering was chosen as the most suitable method for segmenting customer data due to its simplicity, computational efficiency, and ease of interpretation. This method is recognized as an effective clustering technique for large datasets as it allows efficient separation of data into distinct groups based on key features such as customer satisfaction and visit frequency. This method is especially useful when the data is relatively simple, making it easier to interpret, which makes it a valuable tool for analyzing customer behavior.

One of the standout strengths of K-means clustering is its ability to process large datasets quickly, making it an ideal choice for customer segmentation tasks. Using tools like Orange software, this algorithm can be executed quickly to automatically identify different customer segments based on their behavioral patterns. The algorithm works by assigning data points to the nearest cluster center and iteratively adjusting the cluster centers until convergence. This inherent simplicity and computational efficiency

make the K-means algorithm a powerful and accessible tool for businesses looking to analyze and segment their customers.

Data analysis revealed that there are four main customer clusters, each with distinct patterns of satisfaction and browsing behavior. These clusters can serve as the foundation for targeted marketing strategies to optimize customer interaction:

• Cluster 1: Customers with moderate satisfaction who browse several times a week. The main goal for this group is to increase overall satisfaction. Offering special discounts, coupons, or exclusive offers could encourage them to interact more and increase their likelihood of purchasing. Additionally, providing feedback channels through surveys or direct communication can help identify factors affecting their satisfaction and improve the overall customer experience.

• Cluster 2: Customers with high satisfaction who browse frequently. Given their high satisfaction and engagement, loyalty programs would be very effective for this group. Rewarding their continuous interaction with personalized offers, special discounts, and other incentives can strengthen their relationship with the brand. Regular updates on new products or services, along with benefits such as early access to sales or special discounts, can further increase their loyalty and lifetime customer value.

• Cluster 3: Customers who browse frequently and have high satisfaction. Building deeper relationships with this group through exclusive and personalized offers is essential. Since these customers are already highly satisfied, providing time-limited discounts, special offers, or early access to new products can strengthen their loyalty. Additionally, offering educational content—such as guides, tutorials, or product tips—can further increase their engagement. Enhanced post-sale support and follow-up communication to gather feedback can also help strengthen this group.

• Cluster 4: Customers with moderate satisfaction who browse frequently. The main objective for this group is to increase satisfaction and build greater loyalty. Conducting targeted surveys or gathering feedback to understand their concerns is

Table 2.

Situate score in clustering algorithms

Method	Situate score
K-means	0.72
DBSCAN	0.65
Hierarchical	0.58
PCA	0.50

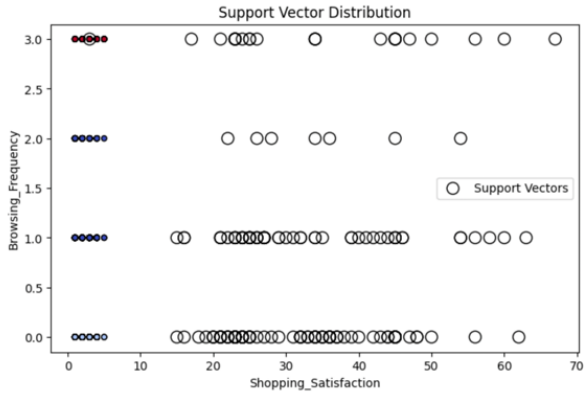
Given the superior performance of the K-means algorithm in clustering customer data, this method was chosen as the primary basis for implementing classification techniques. Accordingly, the clusters obtained from this algorithm were used as class labels. The labeling process was performed manually, where each data point received a specific label based on the cluster assigned by the K-means algorithm. This step prepared the data for the application of various classification methods, allowing their effectiveness in predicting customer behavior to be evaluated.

Upon applying the first classification method, the Support Vector Machines (SVM) approach, the results from this model, including the support vectors, confusion matrix, and performance evaluation report, demonstrate the overall model's effectiveness in classifying customer behavior.

The following chart displays the support vectors in the feature space of purchase

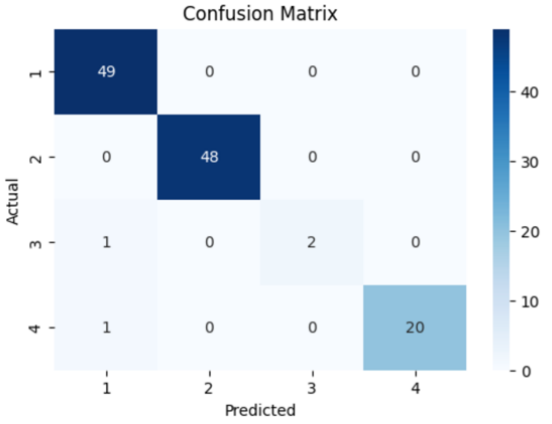
satisfaction and search frequency. The support vectors, which play a critical role in defining the decision boundaries of the model, are highlighted with circles. The presence of these points indicates that the classification structure.

Figure 1.
SVM classification



The confusion matrix below illustrates the performance of the Support Vector Machine (SVM) model in predicting the different classes of the dataset. It can be observed that the model has accurately classified most of the samples with high precision. However, a few misclassifications are seen in the third class, which may indicate the model's difficulty in distinguishing this particular class.

Figure 2.
SVM confusion matrix



The model evaluation report indicates that the Support Vector Machine (SVM) algorithm was able to classify 98% of the available data with high accuracy. The precision, recall (sensitivity), and F1 score for each class were calculated, showing that the model performed well in most classes. The decrease in recall (sensitivity) in the third class suggests that some samples from this class were not correctly identified, which could be due to the imbalanced distribution of the data.

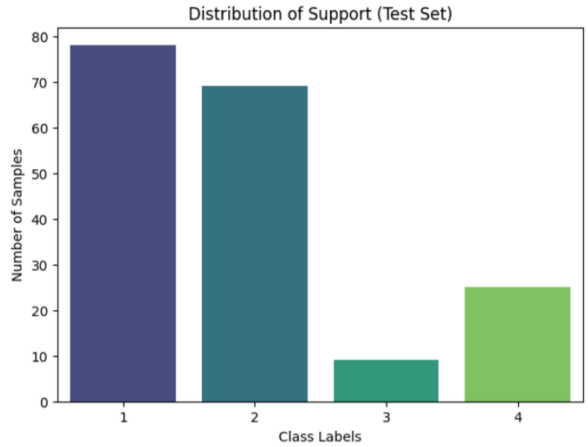
Table 3.
SVM classification performance report

Accurcy: 0.98	**precision**	**recall**	**F1-score**	**support**
1	0.96	1.00	0.98	49
2	1.00	1.00	1.00	48
3	1.00	0.67	0.80	3
4	1.00	0.95	0.98	21
Accuracy			0.98	121
Macro avg	0.99	0.90	0.94	121
Weighted avg	0.98	0.98	0.98	121

The Random Forest model, applied to the selected dataset, provides results that require thorough analysis and examination. Initially, the distribution of data in the test set reveals that the different classes have an imbalanced number of samples. Class 1 has the highest number of samples (78 samples), while Classes 3 and 4 have fewer samples (9 and 25

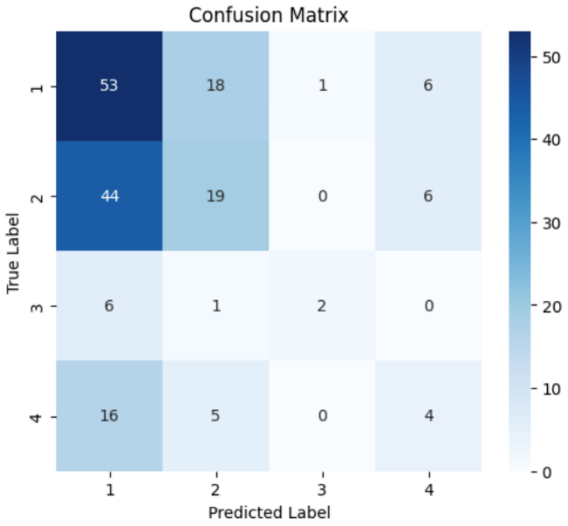
samples, respectively), resulting in an imbalance. This data imbalance can significantly affect the model's performance, particularly for classes with fewer samples, as the model tends to predict the more frequent classes more often.

Figure 3.
Random forest classification



The confusion matrix of the model shows that Class 1 has the highest correct identification rate; however, some of its samples have still been misclassified into Class 2. On the other hand, Class 2 performs poorly, with many of its samples incorrectly predicted as Class 1. This issue is much more pronounced in Classes 3 and 4, where the model has correctly classified only a few samples, and in most cases, it has assigned them to Class 1. This suggests that the model struggles with classes that have fewer samples and requires further improvement.

Figure 4.
Random forest confusion matrix



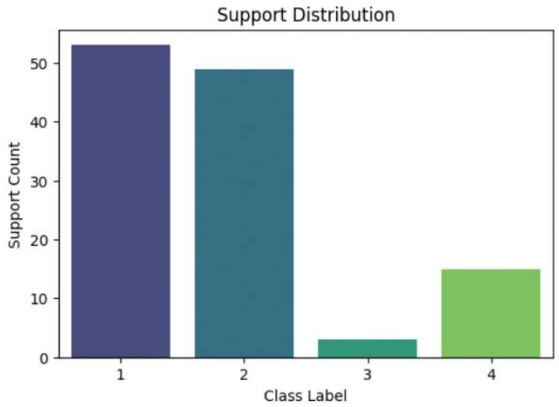
Performance report of this model further confirms this issue. The model achieves a precision of 0.45 and recall of 0.68 for Class 1, indicating that it correctly identifies most of the samples in this class. However, precision and recall sharply decline in Classes 2, 3, and 4. For instance, the recall for Class 3 is only 0.22, and for Class 4, it is 0.16, suggesting that the model struggles significantly in recognizing these classes. Additionally, the overall precision of the model is 0.43, reflecting a moderate performance. The weighted average F1-score is 0.40, emphasizing that the model faces challenges in achieving a balanced distribution of predictions. The main issue with the model is class imbalance and its tendency to predict more frequent classes.

Table 4.
Random forest classification performance report

Accurcy: 0.43	**precision**	**recall**	**F1-score**	**support**
1	0.45	0.68	0.54	78
2	0.44	0.28	0.34	69
3	0.67	0.22	0.33	9
4	0.25	0.16	0.20	25
Accuracy			0.43	181
Macro avg	0.45	0.33	0.35	181
Weighted avg	0.43	0.43	0.40	181

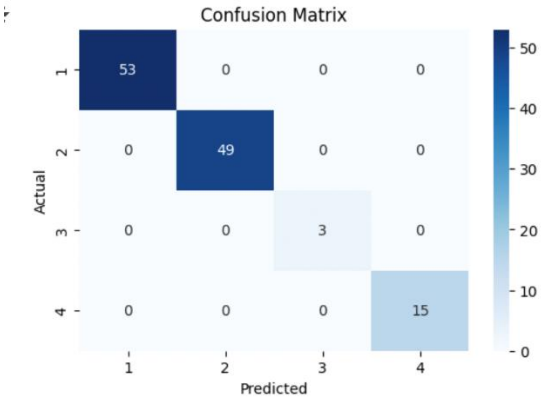
The results obtained from executing the Gradient Boosting algorithm on the dataset indicate the excellent performance of this model in classifying customer behavior. The support distribution chart shows that the highest number of samples belong to Classes 1 and 2, while Classes 3 and 4 have fewer samples. This distribution indicates that some customer groups are predominant in the reviewed data, while others are in the minority.

Figure 5.
Gradient boosting classification



The results obtained from executing the Gradient Boosting algorithm on the dataset indicate the excellent performance of this model in classifying customer behavior. The support distribution chart shows that the highest number of samples belong to Classes 1 and 2, while Classes 3 and 4 have fewer samples. This distribution indicates that some customer groups are predominant in the reviewed data, while others are in the minority.

Figure 6.
Gradient boosting confusion matrix



The results obtained from executing the Gradient Boosting algorithm on the dataset indicate the excellent performance of this model in classifying customer behavior. The support distribution chart shows that the highest number of samples belong to Classes 1 and 2, while Classes 3 and 4 have fewer samples. This distribution indicates that some customer groups are predominant in the reviewed data, while others are in the minority.

Table 5.
Gradient boosting classification performance report

Accurcy: 1.00	**precision**	**recall**	**F1-score**	**support**
1	1.00	1.00	1.00	53
2	1.00	1.00	1.00	49
3	1.00	1.00	1.00	3
4	1.00	1.00	1.00	15
Accuracy			1.00	120
Macro avg	1.00	1.00	1.00	120
Weighted avg	1.00	1.00	1.00	120

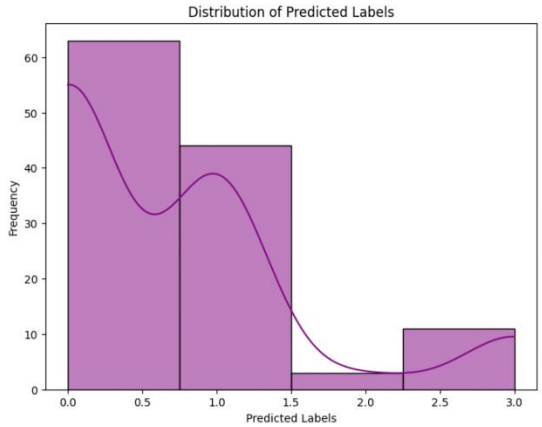
Overall, these results indicate that the Gradient Boosting model, using the selected features, has been able to predict customer behavior with very high accuracy. This high accuracy enables the use of this model in

analyzing customer behavior and designing data-driven marketing strategies.

Regarding the performance of the XGBoost model on the Amazon Customer Behavior Survey dataset, the predicted label distribution chart provides valuable insights into the model's behavior. Analyzing the distribution of the predicted labels, the chart shows that the model tends to classify most of the samples into Classes 0 and 1, while the number of predicted samples in Classes 2 and 3 is noticeably lower. This distribution could be due to imbalanced training data or the model's limitations in identifying patterns in underrepresented classes. The density curve further confirms this, as the model's focus is predominantly on Classes 0 and 1, with other classes being less identified.

Figure 7.

XGBoost classification

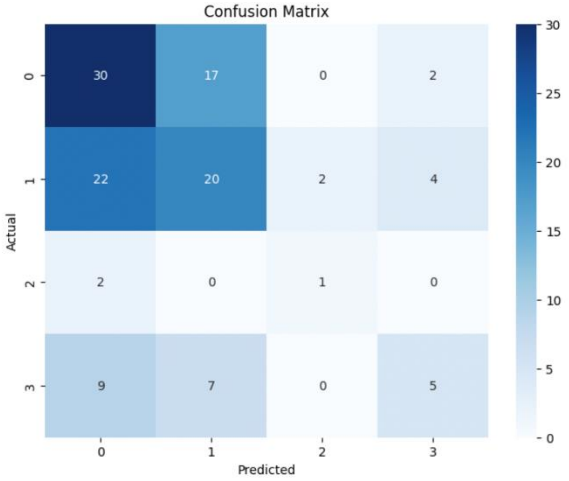


The confusion matrix of this model also indicates that the model has varying accuracy in predicting different classes. The highest correct prediction rate is for Class 0, with 30 samples correctly classified, yet 17 samples are mistakenly classified into Class 1. Additionally, Class 1 shows a moderate performance with 20 correctly predicted samples, but the number of incorrectly predicted samples (22 in Class 0) highlights challenges in distinguishing this class.

For Classes 2 and 3, the model performs more poorly. For Class 2, only 1 sample is correctly classified, and 2 samples are assigned to Class 0, indicating imbalanced data or high similarity between class features. Class 3 also faces low accuracy, as 9 of its samples are placed in Class 0, and 7 samples are placed in Class 1. These results suggest that the model struggles to distinguish specific classes and requires further optimizations.

Figure 8.

XGBoost confusion matrix



The XGBoost model applied to this dataset has an accuracy of 0.4628, indicating relatively poor performance in predicting the clustering labels. The input data includes features such as age, customer review importance, usage of personalized recommendations, rating accuracy, and satisfaction with the purchase. The predicted labels suggest that the model tends to favor a specific class, which may indicate data imbalance or weak features in distinguishing the clusters. To improve the model's performance, new features could be added, the data could be balanced, or parameter optimization techniques, such as hyperparameter tuning, could be utilized.

Table 6.

XGBoost classification performance report

Accuracy: 0.46	**age**	**Review_Importance**	**Personalized_Recommendation_Frequency**
0	23	3	3
1	23	1	2
2	34	2	4
3	23	3	3
4	23	3	3
	Rating_Accuracy	**Shopping_Satisfaction**	**Cluster_Label**
0	3	3	3
1	2	2	2
2	4	4	3
3	2	3	3
4	3	3	3

Conclusion

The results above indicate that XGBoost has performed well in classifying certain classes but faces challenges in distinguishing specific classes. To enhance the model's performance, it is suggested to utilize techniques such as data augmentation, class weight adjustment, alternative metrics like the F1-score, or the use of ensemble algorithms to increase prediction accuracy for underrepresented classes.

The results also show that the gradient-boosting model achieved optimal performance with 100% accuracy. However, this value might indicate overfitting, particularly if the test data size is limited. In contrast, the Support Vector Machine (SVM) algorithm achieved 98% accuracy, demonstrating very good performance with results close to optimal without showing signs of overfitting. On the other hand, the Random Forest and XGBoost models showed weaker performance, with accuracies of 40% and 46%, respectively, indicating their inability to generalize well for this dataset.

Based on this analysis, the Support Vector Machine (SVM) algorithm is selected as the best classification method for this dataset, as it not only provides high accuracy but also avoids overfitting and demonstrates better generalizability.

Table 7.

Classification methods accuracy

Method	**Accuracy**
Gradient Boost	100%
SVM	**98%**
XGBoost	46%
Random Forest	40%

The results of this study indicate that various clustering and classification methods demonstrated different performances in analyzing customer behavior. In the clustering section, the K-means method, being one of the most widely used, successfully divided customers into meaningful clusters based on their satisfaction with purchases and browsing frequency. The analysis of these clusters reveals that increased customer interaction and page browsing are often associated with higher satisfaction levels. On the other hand, the hierarchical clustering method provided a more flexible analysis of customer clusters and displayed customer relationships in a more structured manner. This method is suitable for strategic decision-making but is computationally more complex when dealing with large datasets. Additionally, methods

such as principal component analysis and density-based clustering were also implemented, each showing its own strengths and weaknesses.

In the classification section, four algorithms—Support Vector Machine (SVM), Random Forest, Gradient Boosting, and XGBoost—were examined. The results showed that the SVM algorithm, with an accuracy of 98%, performed better in predicting cluster labels, and accurately classifying customers into appropriate groups. The Gradient Boosting model, with an accuracy of 100%, showed excellent performance; however, this could indicate overfitting, particularly if the test data size is small. In contrast, the Random Forest and XGBoost models, with accuracies of 40% and 46%, respectively, showed weaker generalization performance, indicating their inability to predict customer categories accurately.

Overall, the findings of this study confirm that combining clustering and classification methods can be an effective tool for analyzing customer behavior in data-driven marketing. Among the methods reviewed, the Support Vector Machine (SVM) algorithm is selected as the best classification method for this dataset, as it not only provides high accuracy but also avoids overfitting and demonstrates better generalization.

Based on the results of this study, several recommendations are proposed to improve the accuracy of customer behavior analysis models and enhance the effectiveness of classification methods. First, increasing the volume of data and utilizing data augmentation techniques can help balance the classes and improve the performance of classification models. Imbalanced data may negatively impact the performance of machine learning algorithms, so applying data augmentation methods can enhance the generalization of models.

In addition, optimizing classification models through fine-tuning hyperparameters can contribute to improving prediction accuracy. Optimizing key parameters, such as the learning rate in gradient boosting algorithms, and utilizing comprehensive evaluation methods like the F1-Score, can reduce error rates and improve model performance. Furthermore, employing ensemble models, such as combining Support Vector Machine (SVM) and XGBoost algorithms, can increase overall classification accuracy and mitigate the weaknesses of each individual model.

Finally, improving data quality and applying advanced preprocessing techniques can have a significant impact on enhancing the accuracy of machine learning models. Removing noise, standardizing features, and reducing data dimensions using methods like Principal Component Analysis (PCA) not only reduces computational complexity but also improves model prediction accuracy. Therefore, implementing these solutions can be effective in improving customer behavior analysis and optimizing data-driven marketing strategies.

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RESEARCH ARTICLE **Open Access**

Scientific Mapping for Customer Lifetime Value Research in Organizations Using Cluster Analysis Method

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Abstract
The aim of this research is to analyze and map international scientific publications related to Customer Lifetime Value (CLTV). This study adopts an interpretive paradigm and employs a descriptive approach using a systematic review method. By utilizing specific search terms in the Web of Science database, covering the period from 1985 to 2024, and after thorough screening and qualitative assessment of the studies, the final analysis was conducted on 639 articles. An in-depth examination of the selected articles revealed a notable increase in international research in this field, particularly during the last twenty years. However, there have been periods of decreased research activity in years such as 2008, 2017, and 2023. The primary focus of this research has been on customer lifetime value and customer segmentation, with a significant association to the keyword "data mining," highlighting the importance of this technique in the discipline. Moreover, it was found that countries like Iran, Canada, and Turkey have lower average citation rates, whereas the United States, France, and Germany exhibit higher average citation rates. This suggests different patterns of co-authorship among these countries. By examining the most and least productive countries and researchers through scientometrics, new research opportunities in the field of customer lifetime value can be identified, providing insights for Iranian researchers to enhance the visibility of their findings on an international scale.
Keywords: *Customer Lifetime Value, Systematic Review, Scientometrics, Cluster Analysis*

Introduction

Customer Lifetime Value (CLV) is a crucial concept in marketing and customer relationship management. It estimates the financial value of all interactions a customer has with a business or brand throughout their relationship (Segarra-Moliner & Moliner-Tena, 2024). This concept represents the approximate revenue or profit a customer contributes to a business over an extended period. CLV plays a significant role in enhancing the profitability of businesses by examining the total value generated by a customer during their relationship with a brand (Valentini et al., 2024).

Customer lifecycle management encompasses a cycle that starts with managing customer information to define behaviors, and includes all processes a business undertakes—from attracting customers to selling products or services and maintaining long-term relationships. The primary goal of customer lifecycle management is to integrate customers deeply

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into the business so that they remain profitable over time. It involves a combination of processes, technologies, and tools aimed at adding value to the customer's lifetime (Valli, 2024).

With increasing global competition and the rising importance of effective customer communication, it is crucial to remember that retaining existing customers is significantly less expensive than acquiring new ones (De Marco et al., 2021). Additionally, in light of global financial crises, businesses are striving to manage costs and revenues effectively. As a result, managers and decision-makers are seeking effective strategies to retain customers, establish long-term relationships, and enhance the brand's share of a customer's wallet (Dandis et al., 2022).

Consequently, more researchers are focusing on CLV to understand the need for businesses to develop suitable operational approaches to enhance customer lifetime value. A review of the literature in this field reveals various methods for calculating customer lifetime value (CLTV), starting with the foundational formula of revenue minus the total sales and promotion costs introduced by Berger and Nasr (1998). Subsequently, researchers have employed methods like probabilistic models (Jasek et al., 2019), economic models (Baidya et al., 2019), sustainability models focusing on customer purchasing behavior and retention (Chan et al., 2011), computer science models utilizing techniques such as neural networks and decision trees, as well as growth/diffusion models aimed at forecasting (Venkatesan & Kumar, 2004). However, despite the wealth of research dedicated to CLV, a significant challenge persists: the unclear documentation and systematization of the research trajectory itself (Dust Mohammadi et al.,2016). While individual studies contribute valuable insights, a comprehensive understanding of the field's evolution, its key players, emerging trends, and remaining knowledge gaps remains elusive.

It is evident that conducting scientific research without a thorough understanding of previous studies, including their strengths and gaps, can lead to significant resource waste. Therefore, researchers across all scientific disciplines, particularly in fields related to human factors like marketing and customer lifetime value, should critically review past research before initiating their studies. Scientometric methods provide researchers with a comprehensive overview, presented in the form of maps and thematic clusters, allowing for in-depth analyses of prominent researchers, commonly used keywords, overlooked keywords, active countries, and organizations that provide research funding.

Therefore, this study directly addresses the critical need for a clear and comprehensive map of the CLV research landscape. It aims to systematically analyze the existing body of literature using scientometric methods, providing a visual and thematic overview of the field's evolution, key contributors, dominant research themes, and under-explored areas. By leveraging the power of cluster analysis, this research seeks to answer the following key questions:

- What are the dominant research themes and trends within the CLV literature?
- Who are the key researchers and institutions shaping the field?
- Which keywords and concepts are frequently used, and which are comparatively overlooked?

- Which countries and organizations are most active in CLV research and funding?
- What are the key knowledge gaps and potential avenues for future research?

In this spirit, the current study aims to map the scientific landscape of customer lifetime value research in organizations using cluster analysis. To support Iranian researchers interested in this field, initial data were collected from the reputable Web of Science database, which is one of the most comprehensive and reliable sources indexing international articles. This data will then be analyzed using scientometric methods to offer a clear picture of the research trajectory concerning this important concept in business administration. The findings will assist Iranian researchers in making informed decisions regarding keyword selection, identifying potential international collaborators, and publishing their research in reputable international journals with a well-rounded understanding.

Theoretical Framework

In today's competitive cloud environment, globalization, constant change, and innovation have fundamentally transformed lifestyles and consumption patterns. The impermanence of everything, including competitive advantages, is now a defining characteristic, making traditional competition methods and market understanding insufficient. Brands and businesses need to leverage resources beyond past competitive capabilities to navigate these transformations and maintain their prominent position in the minds of their audience amid the accelerating wave of change (Kumar, 2018).

The only constant in today's world is change, which has revolutionized the way modern humans live. This fundamental transformation affects both individuals as consumers and businesses alike (Sancak, 2023). In the dynamic and turbulent market landscape, businesses are seeking sustainable competitive advantages to retain existing customers at a lower cost than acquiring new ones (Rane et al., 2023).

Customer lifecycle value is essential for categorizing customers and understanding their diverse behaviors. This approach enables businesses to provide unique sales offers that enhance customer loyalty (Čermák, 2015). Customer lifetime value (CLV) represents the amount of value a customer is expected to bring to a business over a specific time horizon. It is directly related to the benefits derived from that customer group (Razmi & Ghanbari, 2009).

CLV provides service providers and product sellers with insights into their customers' situations, facilitating the development of appropriate communication channels and retention strategies. By analyzing available customer information, businesses can calculate and predict profitability, leading to informed decisions regarding customer management. The concept of customer lifetime value originates from customer relationship management and is a fundamental principle in this field (Asadi Ejgerdi & Kazerooni, 2024).

Recent years have seen significant scientific and practical research focused on developing statistical methods to calculate customer lifetime value. Most studies emphasize the net present value derived from customer transactions over their lifetime and model this concept based on customer retention and migration behaviors. Another major method for calculating CLV is the "share of wallet" approach, which compares

the sales of a specific product by an organization to the total purchases of that product by customers in the entire market over a certain period (Razmi & Ghanbari, 2009).

In various calculations, Markov chain models are often employed as a foundation for analyzing customer behavior. In this model, the primary criterion for classifying customers is the amount of revenue they contribute to the organization. This approach is based on the premise that customers do not generate the same profit for the organization (Castéran et al., 2021).

Another method focuses on the customer's historical value, where past performance is indicative of future profitability. This technique utilizes the total profit earned from past interactions as a measure of the customer's future value. By considering the time value of money, profit amounts are adjusted to reflect their present value, establishing a basis for estimating the customer's future worth (Ghale et al., 2021).

In each of these approaches, researchers aim to develop criteria that help manage business expenditures and investments for customers with varying levels of loyalty. By leveraging the profit and income generated from each customer, businesses can establish effective communication paths and allocate resources more efficiently.

An important aspect of customer lifetime value (CLV) research, beyond the various measurement methods, includes the relevant variables referenced in article keywords, the countries where this research originated, and the researchers who have contributed significantly to this field. These factors can help inform future studies through scientific analysis.

A review of the literature on CLV has highlighted that the concept of considering customers as assets that require management and valuation is now widely accepted by both academics and practitioners (Hajmohamad et al., 2020). Given the emphasis on customer relationship management, understanding CLV has become increasingly important. CLV models serve as efficient tools for evaluating a company's relationship with its customers, particularly in enhancing customer-centric services. Researchers in this paper critically review the development of the CLV concept and its various applications (Chang et al., 2012).

Another study conducts an empirical statistical analysis discussing the predictive capabilities of selected CLV models suitable for e-commerce. The comparison includes models such as the extended Pareto model, Markov chain model, and status quo model, evaluated against six online store datasets with annual revenues in the millions of euros. The results indicate that the extended Pareto model outperforms the other models in most evaluation criteria and is particularly effective for non-contractual relationships in online shopping (Jasek et al., 2018).

Additionally, customer lifetime value has been identified as a reliable metric for measuring customer profitability in direct marketing. This has spurred competition among researchers to develop models that maximize CLV and strengthen the company's brand and customer relationships. A review article examines the role of dynamic programming models in enhancing CLV in direct marketing. It begins by assessing basic models that calculate, measure, simulate, optimize, or maximize CLV, before delving into dynamic programming models, including the Markov decision process and

approximate dynamic programming (AboElHamd et al., 2020).

In another literature review, researchers define customer lifetime value as a company's estimate of a customer's net worth over time. This paper discusses CLV's strategic significance in managing profitable customer relationships, addressing three key questions: what, how, and why. The "what" section clarifies the concept and definition of CLV, along with its drivers. The "how" section focuses on measuring CLV and provides an overview of common modeling approaches, including recent advancements. Lastly, the "why" section examines the benefits of adopting a CLV-based management approach, emphasizing the financial impacts such as reduced marketing costs, improved customer response rates, and, most importantly, enhanced overall profitability for both customers and the company (Kumar & Rajan, 2020).

In a study focused on customer lifetime value (CLV) as a fundamental concept in relationship marketing, researchers noted that while CLV has gained attention in both academic and business literature, significant gaps still exist that limit its practical application in business contexts. This paper aims to clarify the research trends concerning CLV by critically analyzing the existing literature. The study will reveal the research area, explore the concepts of CLV, review proposed mathematical models, and examine associated techniques and categories, along with their applications and limitations. The research highlights the need for a comprehensive model to enhance the practical use of CLV (Abdolvand et al., 2021).

Another study aimed to explore the factors influencing customer lifetime value for internet service providers in Jordan. Key factors included technical quality, performance quality, brand reputation, assurance benefits, special treatment benefits, customer satisfaction, and customer commitment. The researchers conducted an online survey with a sample of 481 respondents, utilizing SPSS for data analysis and SmartPLS to test the robustness of the results. Findings revealed that assurance benefits, special treatment benefits, and brand reputation significantly influenced customer satisfaction and commitment. Notably, brand reputation was identified as the most impactful factor driving both customer satisfaction and commitment, ultimately affecting CLV. Furthermore, the study found a negligible relationship between performance quality, technical quality, and customer satisfaction (Dandis et al., 2022).

A study was conducted to investigate the effect of relationship marketing on customer lifetime value, with a focus on the mediating role of relationship quality. This study was descriptive and correlational in nature, utilizing a questionnaire for data collection. The statistical population included customers of Mellat Bank across 21 branches in Tabriz city, from which 384 questionnaires were collected using a convenience sampling method.

Data analysis, performed using structural equation modeling, revealed that relationship marketing has a positive and significant direct effect on customer lifetime value, indicated by a path coefficient of 0.51. Additionally, it positively affects relationship quality, with a path coefficient of 0.57. Furthermore, relationship marketing has an indirect effect on customer lifetime value through relationship quality, also with a path coefficient of 0.51. The significance of both

direct and indirect effects suggests that relationship quality serves as a partial mediator in this relationship. By investing in relationship marketing and enhancing relationship quality, banks can foster effective relationships with customers and subsequently increase customer lifetime value (Rahimiaghdam et al., 2021).

A review of the existing literature emphasizes the importance of thoroughly examining the concept of customer lifetime value, highlighting the variety of perspectives as well as empirical and review research in this area. Accordingly, this study undertakes a scientometric and systematic review of articles published on this topic.

Methodology

The current research employs an interpretive paradigm, which is fundamental for its orientation, utilizing a meta-synthesis strategy and an inductive approach. The exploratory approach predominates the research, which is cross-sectional and yields qualitative results. The statistical population consists of articles indexed in the Web of Science database from 1985 to 2024. After screening and qualitatively evaluating these studies, final analysis was conducted on a purposively selected sample of 639 articles. This study is classified as a scientometric investigation, employing various scientometric indicators and social network analysis for both authorship and lexical occurrences. The scientometric analyses provide quantitative insights into social developments and dynamics, which are crucial for scientific advancement. This is because the conceptual development of any scientific topic requires the application of diverse and innovative methods to identify research gaps.

To achieve this, scientific mapping was performed (Jafariyan et al., 2021). Initially, the term "Customer Lifetime Value" was searched in the subject section of the Web of Science citation database. Articles in languages other than English, those published in formats other than research or review articles, and articles from unrelated fields were excluded from the analysis. Ultimately, 639 articles were included in the final analysis.

To enhance the reliability of the research and confirm the quality of the selected articles, the "Critical Assessment Skills Program" was used. Three experts in marketing and customer relations, all holding PhDs and with a history of publishing at least one article in the relevant field, along with experience in executive and managerial positions within the customer relations sector, evaluated the quality of the articles through a ten-option checklist. The selected articles were analyzed using VOSviewer software, which is well-suited for constructing and visualizing bibliometric networks, creating maps based on network data, and exploring these maps (Azhdari et al., 2020).

Findings

After conducting a thorough search, screening, and qualitative evaluation of articles during the scientific screening process to identify relevant studies aligned with the research objectives, we performed a final review of 541 articles. This culminated in a comprehensive analysis of the key authors, countries, and frequently used keywords, presented as a scientific map using VOSviewer software.

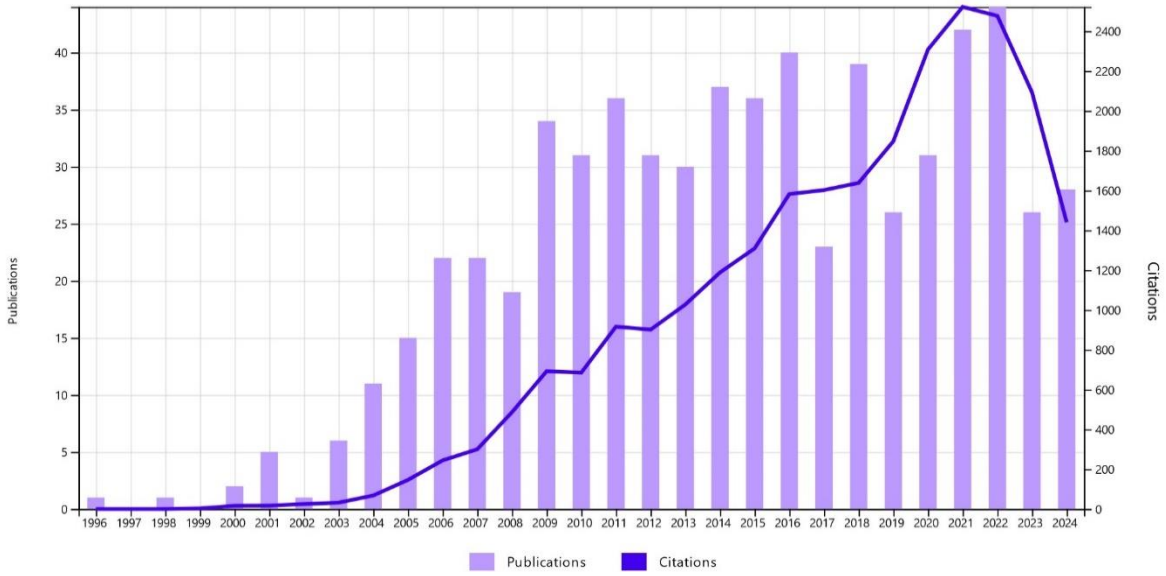
In this study, we examined 639 articles published by various authors, which yielded

an H-index of 81 according to the Web of Science database. This high H-index reflects the scientific credibility of the research conducted in the field of customer lifetime value. Additionally, the average citation per article in this study is 40.01. Given that these 639 articles were cited 25,564 times by a total of 17,149 other articles, it is evident that the research on customer lifetime value holds substantial credibility.

We also analyzed the research trends based on the year of publication and citation rates (Figure 1). According to the Web of Science database, 2022 marked a peak in international research, with 44 articles published and 2,477 citations. While there has been a general upward trend in academic interest in customer lifetime value over the past two decades, there were notable declines in research focus during certain years, specifically 2008, 2017, and 2023.

Figure (1)

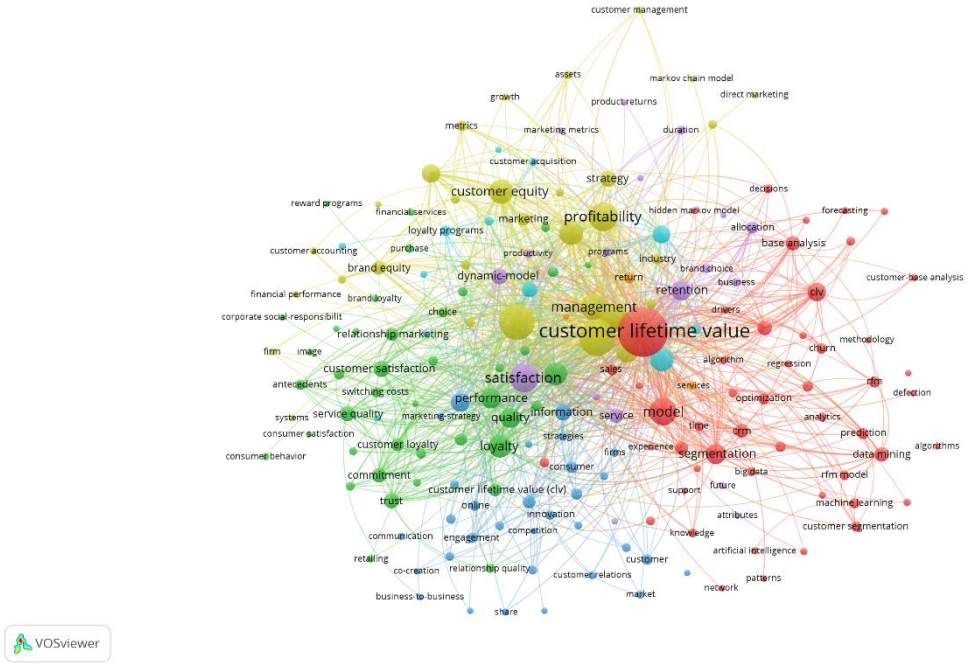
The process of producing scientific studies on customer lifetime value



Scientific Network Maps and Keyword Overlap

The purpose of drawing this map was to understand the structure of relationships between concepts related to the concept of customer lifetime value that have been used by the authors in the articles. In this way, by considering the main axis of each of the research conducted on the subject under study, in addition to identifying new concepts, it is possible to discover outliers but important keywords. For this purpose, all keywords used in the articles were selected as the unit of analysis, and also words that were repeated at least 5 times (threshold) or more are visible in this map. Finally, out of 2596 keywords, 187 words had a minimum threshold value. The results of this analysis can be seen in Figure 2.

Figure (2)
Keyword co-occurrence network map

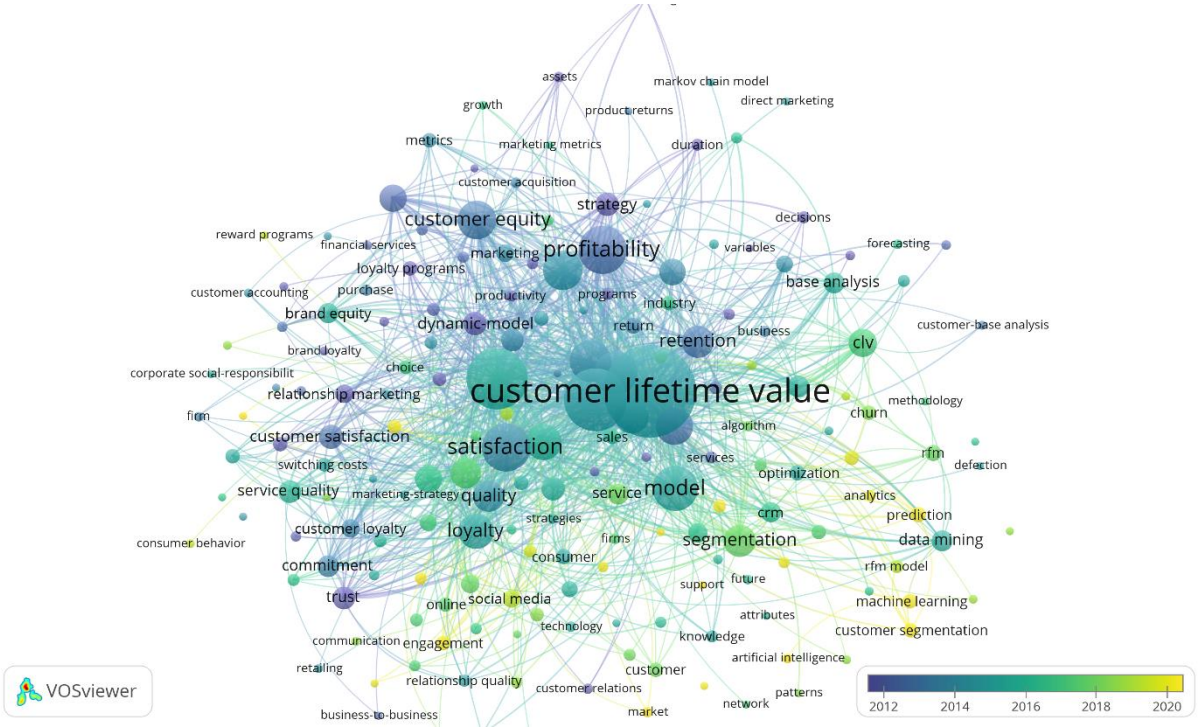


As can be seen in Figure 2, words such as satisfaction, segmentation, profitability, and customer value are associated with the word customer lifetime value, and the keyword that is visible in the center of the figure with a larger circle and has a large diameter in relation to the concept of customer lifetime value and is also in the same cluster as the desired concept is “customer segmentation”. This indicates that more research is being conducted on customer lifetime value and customer segmentation. As is clear from the image, the word customer segmentation is located on the right side of the map and is associated with the keyword datamining, which indicates the importance of this technique in research related to customer lifetime value and customer segmentation.

Figure 3 shows the year-over-year trends in customer lifetime value research. The overlap map visually shows the rise or fall of a keyword. According to the guide bar on the right side of the map, yellow indicates recent keyword usage, and older keywords are blue; in other words, keywords that are dark blue are associated with articles published around 2012 and earlier, and words that are light blue to yellow tend to be published in 2020. In the keyword overlap map, it can be seen that most of the map area is blue-green. This indicates that the main keywords with large circles have been frequently used in recent years. In recent years, concepts such as predicting, machine learning, and artificial intelligence have received attention and will become the focus of research in the near future.

Figure (3)

Overlap map of keyword co-occurrence

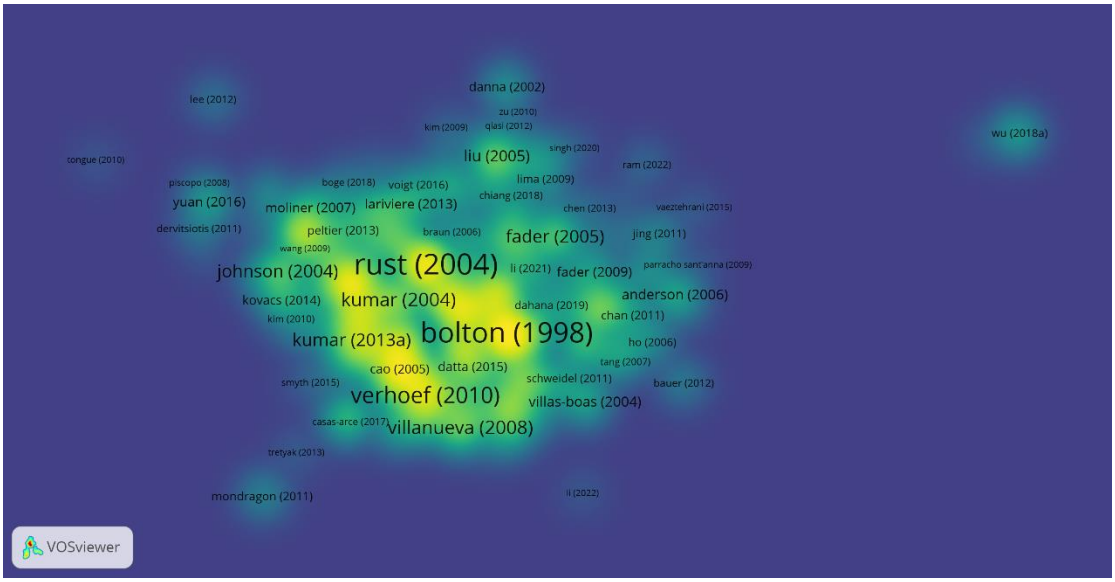


Bibliometric link maps and article author citation maps

Bibliometric linkage, like co-citation, is a similarity measure that uses citation analysis to establish a similar relationship between articles; bibliometric linkage occurs when two articles reference a third article in their bibliometrics. This indicates how likely it is that the two works address a related topic; if both cite one or more common documents, the two documents are bibliometrically paired. The more references two articles make to other documents, the greater the "link strength." Co-citation occurs when two articles are both independently cited by one or more other articles. Since bibliometric linkage has been criticized for its retrospective nature, and because two articles may refer to a completely unrelated topic in a third article, co-citation is a more appropriate indicator of the similarity of the cited topic (Azodi et al., 2024). To plot the bibliometric linkage graph, documents were selected as the unit of analysis and the plotting method in VOSviewer was fractional counting (figure 4). Five citations were selected as the threshold value and out of 639 articles, 437 reached this value; this threshold was chosen to ensure greater accuracy in the analysis. These 437 authors are located in 9 clusters with different colors; as is clear from the figure, the hot spots or points with the most bibliometric linkages are related to the prolific author in the field of customer lifetime value, Kumar, who has strong bibliometric linkages with other authors in different years, followed by Hung.

Figure (4)

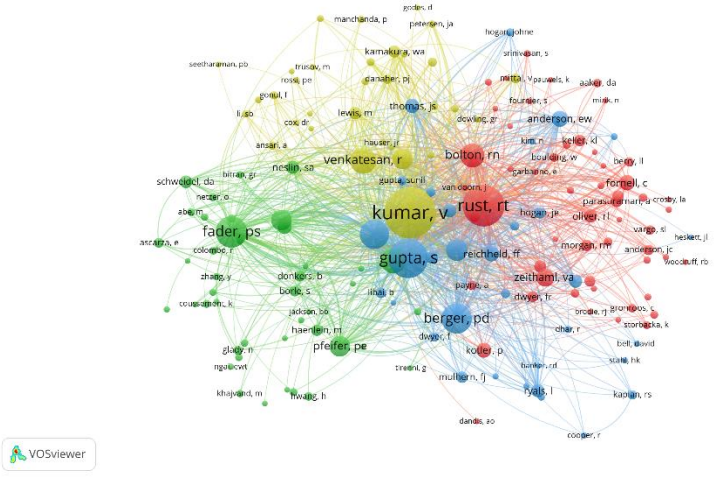
Bibliometric Link Density Map



In the co-citation index, other articles cite two articles simultaneously.; In Figure 5, the relationship between authors and important clusters can be distinguished, and authors in this field are based on a frequency of at least 20 citations, and 164 nodes are obtained from 14,247 authors; Each of these nodes represents articles by an author, which form communication lines between them when co-cited with other articles. The larger the diameter of these circles, or so-called nodes, the more citations are made to that author. In this figure, each color corresponds to a cluster, and each cluster has a connection intensity and hot spots. In the author co-citation network map, Kumar has the largest share of articles in the selected subject area of this study and is located in the center of the graph as the most important author. With 759 citations, he is one of the most active authors. Other authors such as Rust and Gupta are also in the next ranks, but in different clusters with different colors.

Figure (5)

Author Co-Citation Network Map

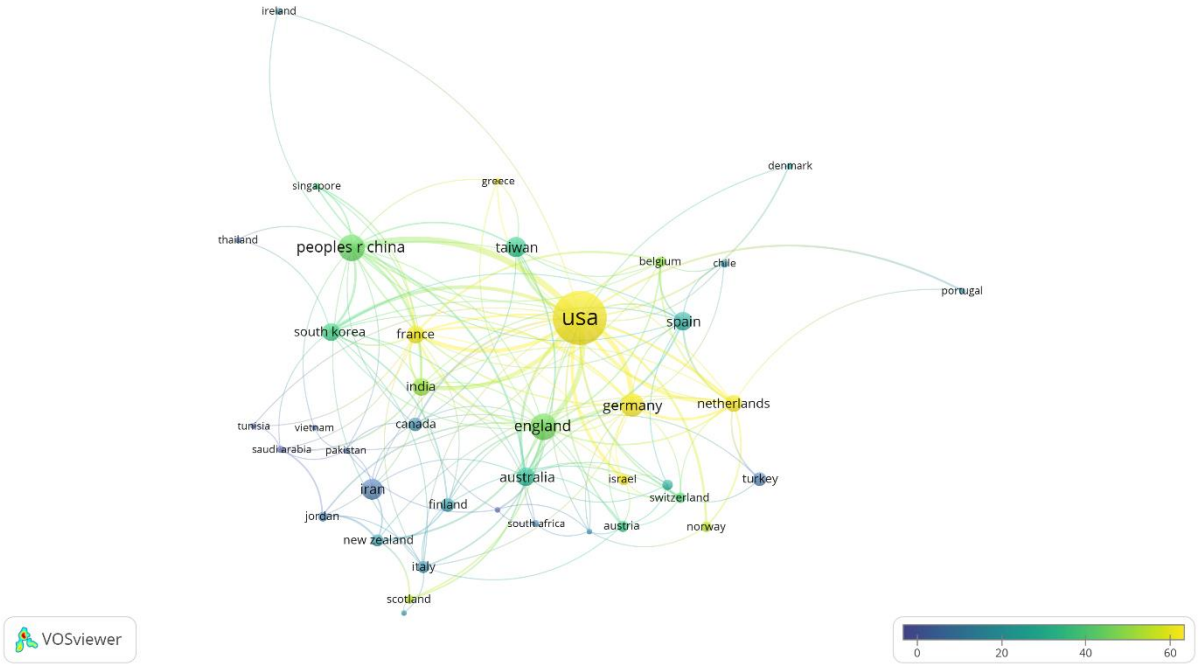


Co-authorship density map of authors from different countries

In analyzing the collaboration of authors from different countries, considering three articles for each country with a threshold of five citations to articles from 64 countries, a co-authorship network of 44 nodes was obtained; In Figure 6, which is the co-authorship density map of authors from countries based on the number of articles and the average citation rate, according to the visual guide on the right and bottom of the map, the average number of citations increases as we move from deep blue to yellow. Accordingly, countries such as Iran, Canada and Turkey have less than twenty and countries such as the United States, France and Germany have more than sixty as the average citation rate, which indicates different co-authorship of these countries; Another important point is that countries such as Denmark, Portugal and Ireland are located in places far from the center and the collaboration of authors from these countries with prominent international researchers is evident with smaller circles and thinner diameters.

Figure (6)

Map of co-authorship network density of countries



Discussion and Conclusion

The aim of this study was to create and analyze a scientific mapping of international research on customer lifetime value using the scientometric method from 1985 to 2024. The study sought to identify the thematic structure of selected articles in the Web of Science database and produce graphical maps illustrating their bibliometric, co-citation, event, and authorship links.

The findings revealed the articles of highly cited and active authors in this field. This not

only provides a pathway for future researchers to explore more frequently cited articles, which likely contain valuable scientific content, but also suggests that by citing active authors from high-performing, research-rich countries, Iranian authors may gain greater recognition in the international research community.

The analysis of co-citation patterns indicated that Iranian authors are underrepresented in these relevant maps. This may result from Iran's limited collaboration as a sponsor of international research and a lack of joint research activities involving Iranian authors and researchers from other countries. Consequently, for Iranian authors to gain visibility worldwide, they should collaborate with leading authors in these fields or reference their works. Support from organizations focusing on research in customer lifetime value could also facilitate the international dissemination of Iranian authors' scientific results.

Moreover, a keyword co-occurrence analysis revealed which topics have garnered more attention and which have received less focus within scientific communities. The results indicated a close relationship between customer lifetime value and concepts such as customer satisfaction and customer segmentation. Data mining techniques, alongside artificial intelligence, have increasingly been employed by researchers in recent years to calculate customer lifetime value. Conversely, some keywords, like financial performance or direct marketing, were identified as outliers, indicating a theoretical connection to customer lifetime value but insufficient usage in concurrent research.

Although scientometric studies do not inherently provide recommendations, they can enhance the understanding of the current state of research and guide trends in the field. Researchers are encouraged to concentrate on hotspots or keywords with broader representation in their studies, as well as on outliers that are less central. By considering both types of nodes, researchers can pave the way for growth in Iranian research in this discipline.

The study's findings on hotspots, or points with significant bibliometric links, highlighted that Kumar is a prolific author in the field of customer lifetime value, maintaining strong bibliometric connections with various authors over the years, followed by Hung. Kumar is central in the author co-citation network map, ranking as the most important author with 759 citations. Other authors, such as Rust and Gupta, also rank highly but are located in different clusters.

This valuable insight helps Iranian researchers utilize a solid foundation of highly cited articles and active authors in analyzing their research background, minimizing redundancy. The study also discovered that countries including Iran, Canada, and Turkey have an average citation rate of less than twenty, while countries like the United States, France, and Germany exceed an average citation rate of over sixty. This suggests differing levels of co-authorship in these regions. Another important observation is that countries such as Denmark, Portugal, and Ireland are positioned further from the center, indicating the collaboration of authors from these nations with prominent international researchers occurs in smaller clusters.

Future researchers are encouraged to leverage the results from countries that are at the forefront of research in customer lifetime value, actively seeking opportunities for

collaboration with both public and private institutions to conduct global research. They should also consider exploring other variables associated with the concept of customer lifetime value.

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RESEARCH ARTICLE **Open Access**

A Digital Transformation Approach to Authenticate Original Products for Foreign Markets

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Abstract
This study presents a novel business model designed to explore the impact of digitalization on product authentication, a field gaining increasing relevance in today's digital economy. Leveraging Near-Field Communication (NFC) technology, the proposed model aims to support the international expansion of original products by establishing a secure product authentication database. Given NFC's widespread adoption for authenticity verification and market development, this research offers a pioneering framework for applying such technology to authenticate Iranian products—particularly in sectors like handicrafts and apparel, which possess strong export potential yet remain underutilized by local industry stakeholders. Beyond authentication, the model enables robust market intelligence gathering, especially in foreign markets where consumer insights are often fragmented. The study employs Osterwalder's business model framework to construct a comprehensive business model canvas, detailing key components such as value propositions, customer segments, and revenue streams. Two distinct service revenue strategies are proposed: a "pay-per-tap" model and a tiered annual subscription plan (Bronze, Silver, and Gold), each tailored to varying levels of service engagement and market needs.

Keywords: *Digital Transformation, Business Model, NFC Technology, Foreign Market Development, Original Products, Product Authentication*

Introduction

Developments in digital technologies have profoundly impacted the business world and its operations. The advent of Industry 4.0, coupled with evolving customer demands, has made changes in business processes essential (Alakaş, 2024; Joel et al., 2024; Yaqub & Alsabban, 2023). Digital transformation is the process of integrating digital technology into all areas of a business, fundamentally changing how it operates and delivers value to customers (Bindeeba, Tukamushaba, & Bakashaba, 2025; Sui, Hu, & Wang, 2024).

The highly volatile and uncertain economic environment nowadays makes management decisions complicated and difficult. In this environment, economic actors should be capable of managing multiple distribution channels, complex supply chains, digital transformation, as well as strategic partnership while remaining flexible in reaction to market changes (Naimi-Sadigh, Chaharsooghi, & Mozafari,

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2021; Santarsiero, Carlucci, & Schiuma, 2024).

Business model is one of the most effective tools to help managers easily describe what their business is and how they should run, evaluate, understand and measure, change, as well as simulate it and also to help them turn their intuitive understanding of their business into an objective understanding. The term business model was one of the keywords that came to the fore with the advent of the Internet (Magretta, 2002) to provide a solution to the complexities of business in today's dynamic and highly competitive industry environment. The business model helps managers better understand and define their value proposition, the way to create this value, the way to select partners, the ways to reach the customer, the way to earn revenue, as well as many other business-related issues (Boffa & Maffei, 2024; Osterwalder, Pigneur, Oliveira, & Ferreira, 2011; Rabiei, Hosseini-Motlagh, Haeri, & Minaei Bidgoli, 2021).

As digital technologies continue to evolve, they drive significant changes in business models across industries. Among these technologies, Near-Field Communication (NFC) has gained global traction for various applications, including product authentication. Although NFC has been available in Iran for several years, its potential for verifying product authenticity remains largely untapped. This gap is particularly critical for Iran’s strategic export products—such as carpets, caviar, and saffron—which enjoy strong demand in international markets but are increasingly vulnerable to counterfeiting and fraud.

The lack of robust authentication mechanisms has not only undermined consumer trust but also harmed domestic producers and exporters, while benefiting foreign competitors and unauthorized traders. Iranian officials have identified product fraud as a pressing issue, yet comprehensive technological solutions have yet to be implemented.

This study addresses this gap by proposing a business model that leverages NFC technology to authenticate original Iranian products and support their expansion into global markets. Beyond enhancing consumer confidence, the model offers valuable market intelligence by capturing geolocation data during authentication events. This data can be used to identify demand hotspots and inform strategic decisions for manufacturers aiming to enter or grow in international markets.

The present article is structured in the following manner: In the next section, the business model will be described, then different types of business models and particularly electronic business (e-business) models will be explained. Later on, NFC technology will be analyzed and then various business models of NFC-based authentication services are presented. Finally, conclusions and practical recommendations are offered.

Background

Business Model

The basic concept of business model was initially termed as "dominant logic". Dominant logic is considered as a set of norms and principles that managers should use to properly organize enterprises and projects and to seek and seize opportunities that arise in the market. This approach, which emphasizes rationality in operations, requires the establishment of specific rules for the management of the enterprise and the project

(Prahalad & Bettis, 1986). Following the emergence of dominant logic, it attracted a great deal of attention in business research.

According to experts, the main concept of the business model is defined as follows:

- Business model is based on the logic of creating and maintaining value (Shafer, Smith, & Linder, 2005).
- Business can be defined as the fundamental logic used by the organization while creating value (Cantrell & Linder, 2000).
- Business model is considered as an exploratory logic that combines the potential of technology with the realization of economic value (Chesbrough & Rosenbloom, 2002).
- Business model provides a conceptual tool that includes a set of elements and the relationships between them, which represent the logic of the enterprise operations and the project in a particular area.
- Business model is a method that should be adopted by the enterprise in order to provide value to a specific group of customers (Johnson & Lafley, 2010).
- Business model is an advanced form of enterprise's organizational management model and shows that this model provides a systematic idea of the paths (business activities) needed for the development of the enterprise and the project (Nogalski, 2009).

Therefore, it can be assumed that the business model is generally identified by the logic of operations; that is the path to be taken or the operational method to be performed in the enterprise and the project.

On the other hand, Grabowska (Grabowska, 2015) creates the cores of the concept of business model based on the dominant logic and considers maintaining value, being inside the customer's value range, being successful in a particular set of initiatives and innovations, achieving the profit zone, taking advantage of business opportunities, and specifying a roadmap as improvement and identifies three main research streams for business model conceptualization:

The first stream is a group of concepts that refers to the concept of value chain. In this area, the concepts of the business model focus on how to create and provide value to customers and then on how to turn customer payments into profits. This approach defines the organizational and financial architecture of the enterprise operations and the project. The second group includes concepts that reflect a resource-based approach and refers to the activities and resources needed to provide products and services to end customers. The third group focuses on developing a business along creating and maintaining value (Grabowska, 2015).

However, other studies, such as Afuah's (Afuah, 2004), that take a holistic approach should also be mentioned. Based on these studies, business model is related to the activities or plans and methods and the time of performing these activities while using sufficient resources to create the highest possible value for the customer (considering low or high product costs) and ensuring the position of the enterprise and the project to gain value. This interpretation of the business model leads to an emphasis on two areas that determine the nature of the model: activities and resources as well as value gain. Value creation is one of the most important features of a business model in both dimensions of value for the customer and value for the enterprise and the project (Afuah, 2004).

Different definitions for business model has led to major challenges in defining the nature and components of the model and

determining the key elements of a good business model. It also causes confusion about the definition of this term, which is why terms such as business model, strategy, business concept, revenue model, and economic model are often used interchangeably. In addition, the business model is often referred to as architecture, design, sample, method, hypotheses, and business proposition (Morris, Schindehutte, & Allen, 2005; Naimi-Sadigh, 2024).

In short, business model is a method any enterprise, corporation, or organization adopts to make profit and sustain itself. The business model describes how an organization creates added value for a product/service. In the business model, according to the available resources and the customer's needs, the customer's desired value is proposed and the organization enjoys benefits and income. In other words, the business model describes how the organization earns revenue by positioning itself in the customer's value chain (Corkindale, 2010).

Business model translates the organization's plans and ideas into economic values and shows how an organization earns revenue by determining its position in the value chain and also includes information about entrepreneurship, strategies, economic issues, investments, activities, and marketing. According to Itami and Nishino (Itami & Nishino, 2010), a business model consists of two sections: the business system and the profitability model. Although the second section often leads to more profit, the first one forms the main body of the business model. This section not only acts as a working system, production basis, and service provision, but also is a section the enterprise can rely on to check the operational work as well as suppliers and customers' behaviors and gain new learning. These lessons learned are accumulated and can lead to a significant competitive advantage, and if the activities are not coherent enough, this competitive advantage could be lost. Although the profitability model increases revenue in the short term, the business system generates information in the long run, thus a successful business model should consider both (Itami & Nishino, 2010).

Business models are organizational tools that show the organization's logic for creating and gaining value as well as the organization's approach to innovation. However, enterprises face obstacles and difficulties in designing their right business models. Discovering and exploiting new business models requires high level of experience, learning, as well as different leadership styles that can facilitate the use of these new models by increasing general capabilities and flexibility (Svejenova, Planellas, & Vives, 2010).

Digital transformation Models

Since the stated authentication database can turn into a digital transformation, this section deals with e-business models and its definition. E-business models are web-based methods, concepts, frameworks, or architectures that, while considering enterprises' strategies, help them with determining their market position, value proposition to stakeholders, and maintaining their business (Lam & Harrison-Walker, 2003).

E-business model is a general term referring to business processes run in virtual spaces (or electronic ones such as the World Wide Web) (Heshmatisafa & Seppänen,

2023; Shafiee Nikabadi, 2008). E-business models are descriptions of roles and relationships between customers, consumers, partners, and suppliers and seek to identify key product, information, and money flows as well as to identify main benefits for shareholders and business partners. These models use the Internet to interact and create value for the customer and other stakeholders (Currie, 2004; Merín-Rodrigáñez, Dasí, & Alegre, 2024).

According to Timmers (Timmers, 1999), an e-business model contains components (such as customer domain, service/product, and resources), links (effects of one activity on other activities), and dynamics (the organization's response to change to gain a competitive advantage) (Hayes & Finnegan, 2005; Lin, Li, Mahmood, Guo, & Qian, 2024).

E-business models are described in terms of supplier and buyer value chains, IT architectures and systems, technical platforms, and security and traffic scales (Shirou, Yusuke, Satoshi, & Atsushi, 2007).

Lam and Harrison-Walker (Lam & Harrison-Walker, 2003) have estimated that there exist about 50 business models; thus, each of these models are described from a different perspective. Given the breadth and diversity of existing e-business models, there are different factors and criteria for classifying e-business models (Lam & Harrison-Walker, 2003).

Ticoll et al. (Ticoll, Tapscott, & Lowy, 2000) presented four different types of e-business models, and Timmers considered 11 e-business models for the business-to-business (B2B) domain (Timmers, 1999). Rappa (Rappa, 2010) proposed 8 categories for e-business models and defined 36 models (Hayes & Finnegan, 2005).

Near Field Communication Technology

In recent years, the spread of the use of radio frequency identification (RFID) technology in different fields has provoked IT enterprises to think about utilizing this technology in mobile devices. This thought led to the emergence of a new type of technology called NFC. This technology was initially invented in 1983 and approved as an ISO/International Electrotechnical Commission (IEC) standard in 2003. This smart technology includes mobile devices with NFC, NFC reader, and NFC tag (Coskun, Ok, & Ozdenizci, 2011). The hardware components of this technology are comprised of an NFC-enabled mobile phone including a radio frequency setup, a baseband processor, an NFC controller with an antenna, as well as a secure smart chip known as the secure element (Vazquez-Briseno et al., 2012).

This technology is a simple and user-friendly communication technology that has many usages and is being increasingly used in different fields. Some usages of this technology are pointed out below:

- Utilizing this technology in medicine such as in heart rate monitoring (Gopichand, Chaitanya, & Kumar, 2013), storing medical records, better diagnosis, inventory tracking, medication care, blood transfusion, monitoring health professionals' status (Ahson & Ilyas, 2011);
- One of the main applications of NFC is mobile payment and using it as a wallet. Practical examples include paying at in-store electronic terminals, purchasing tickets for public transportation such as airplane, train, and subway, as well as using an NFC-enabled device as an entrance ticket;
- Using the NFC tag on ID cards;

Using a mobile phone equipped with NFC technology as an electronic key for hotels, the house, the workplace, cars as well as using it for logging in to a personal computer;

- Using a mobile phone equipped with NFC technology as a guide in different places;
- Using NFC technology to control an organization's inventory of property and to monitor the entrance and exit of employees; And

Using NFC technology to make universities and educational affairs smarter; for instance, holding exam sessions (Naghavi, Rajabi Ragheb, & Abbasi, 2014) and providing access to bibliographic resources in the university environment (Borrego-Jaraba, García, Ruiz, & Gómez-Nieto, 2013).

Although NFC technology has been widely adopted around the world for applications such as secure transactions and product authentication, its strategic use in Iran—particularly for verifying the authenticity of high-value export goods—remains significantly underdeveloped. Despite the availability of this technology, there has been no systematic effort to implement NFC-based solutions for authenticating Iranian products such as carpets, handy craft, and saffron, which are highly valued in international markets. Moreover, existing research lacks a comprehensive business model that integrates NFC authentication with the commercial and strategic needs of Iranian producers. Another overlooked aspect is the potential of NFC systems to collect geolocation data during authentication events, which could serve as a powerful tool for market intelligence and identifying demand patterns abroad. Furthermore, current approaches do not offer integrated solutions that combine authentication with branding, customer engagement, and export strategy—particularly for small and medium-sized enterprises seeking to compete globally. This paper aims to address these gaps by proposing a business model that positions NFC technology as both a safeguard against counterfeiting and a strategic enabler for market development.

Methodology

To address the research questions of this study, a qualitative multi-method approach was adopted, combining both literature review and authentication techniques. This methodological design was chosen to ensure a comprehensive understanding of existing business models and to tailor an appropriate framework for NFC-based authentication services in Iran.

The document analysis component involved an extensive review of Iranian and international literature, including academic publications, industry reports, and existing business model frameworks. This phase provided foundational insights into various classifications of business models, and helped position the authentication database within the broader context of e-business strategies.

The field research component employed semi-structured interviews and focus group discussions to gather contextual and experiential data. Interviews were conducted with key stakeholders and trustees involved in Iran's authenticity and traceability initiatives, including representatives from Iran Code, Shenaseh Kala, Shenasa, Track & Trace & Authentication Control (TTAC), Shabnam, and Esalat-e Salamat. These interviews aimed to uncover the operational

realities, revenue structures, and strategic challenges of existing systems.

Following the interviews, a focused group discussion was held with experts in business modeling and product authentication. This collaborative session facilitated the evaluation and selection of the most suitable business model for NFC-based authentication services. Through consensus, Osterwalder and Pigneur's Business Model Canvas was identified as the most comprehensive and adaptable framework, given its detailed breakdown of product, customer, infrastructure, and financial components, as well as its alignment with marketing principles such as the 4Ps.

This qualitative approach enabled the integration of theoretical insights with practical stakeholder perspectives, ensuring that the proposed business model is both conceptually sound and contextually relevant.

Timmers has qualitatively classified business models into 11 types (Table 1) based on two criteria of innovation and operational integration (Timmers, 1999).

Table 1.

Timmers' Classification of Business Models

No.	Business Model Type	Description
1	Electronic shop(e-shop)	These models are the same as the traditional web-based stores that can be used to market and advertise the enterprise or store and enable online ordering and payment.
2	Electronic procurement (e-procurement)	These models enable electronic bids and supplying electronic and web-based services.
3	Electronic mall(e-mall)	It consists of a collection of e-shops that usually gather together under a supporting umbrella like a famous brand.
4	Electronic mall(e-mall)	These models make it possible to electronically implement the auction bidding mechanism, as in traditional auctions.
5	Virtual community	Establishing virtual interpersonal group communication in which the revenue is generated through collecting membership or advertisement fees. These models can be connected to marketing operations as an add-on plugin to get customer feedback on the product and services received and strengthen the sense of loyalty in customers.
6	Collaboration platforms	These models provide a set of tools and information in an environment to facilitate collaboration between organizations.
7	Third-party marketplaces	These models are suitable for organizations that want to outsource their web-based marketing to a third party enterprise. Third-party marketplaces offer an interface to the suppliers' product catalogue.
8	Value-chain integrator	This model supports organizations that focus on integrating multiple steps of the value chain and create further added value by developing the potential for information flow between those steps.
9	Value chain service provider	These focus on a particular function for the value chain, such as electronic payment or logistics.
10	Information brokerage	It includes a wide range of information services that add value by processing large volumes of data on social networks or in business processes.
11	Trust and other third-party services	Provide credit and security services such as certificate authority, electronic notaries, and other third party services.

Based on the above classification, the authentication database can be considered as an "information mediator" business model since, by processing a huge amount of available data about product owners and end customers, it attempts to create added value and provide an appropriate platform for manufacturers to conduct foreign market research. Turban et al. (Turban, McLean, & Wetherbe, 2002), presented a different

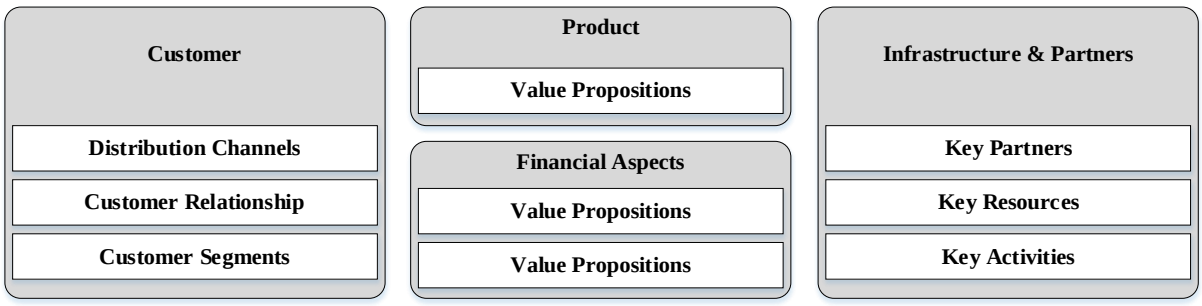
classification compared to other ones and based their classification on the business transaction parties. According to their classification, the authentication database business model that deals initially with the product owners is a B2B model. In the following steps, it can expand to B2C, B2G, and other models. According to Rappa's classification (Rappa, 2010) as well, the authentication database business model is of information mediator type meaning that it tries to provide the information required by the manufacturer, seller, and customers while considering the level of importance of data about products and customers, particularly for marketing or purchase purposes.

The components of Osterwalder and Pigneur's e-business models are divided into two levels. The first level deals with the four major elements of the business model including the product, the customer, the infrastructure and partners, as well as financial management. These concepts are further broken into other elements that ultimately form the nine components of an e-business model. From the researchers' point of view, this model has been chosen as the most appropriate business model because it contains a set of the most comprehensive and appropriate components and sub-components and also provides an overview of the interaction between the main and subsidiary components of the business model. Additionally from a marketing perspective, this model has taken 4Ps into consideration since it takes into account the product features, product quality, key resources utilized to produce the product, key activities, as well as the value created for the customer. In examining the cost structure and revenue model, the distribution, and the promotion components, it considers the product price, the distribution channels, as well as customer relationship and customer segmentation, respectively. Therefore, based upon the components this model takes into consideration, it can be regarded as a comprehensive model for product- or service-based businesses (Osterwalder et al., 2011).

All business models developed by researchers in different industries were explored. As precise and exact identification of the components of these models could define the authentication database position in industries, the components should be elaborated. Among the aforementioned business models, Osterwalder and Pigneur (Osterwalder et al., 2011) adopted a more precise approach to developing e-business models (Figure 1).

Figure 1.

Business Model Components based on Osterwalder and Pigneur's business model canvas



They have proposed components for business models which are referred to as precise definition of e-business examples and their associated components in an enterprise's business model. As regards the relevant literature, Osterwalder and Pigneur's business model could be taken as a more comprehensive model in which a business model is divided into nine components. In this respect, the analysis of the authentication database in the following section is based on this model. This model contains main business components which can be shown and compared with one another on a canvas.

Findings

Revenue Streams

The most important question while developing a business model for the authentication database is how the financial income will be generated. To answer this question, it should be said that the revenue model in Shabnam and Esalat-e Salamat has been in a way that these two businesses as state-owned ones are financially supported by the government and the product owner pays only a small amount for authenticity labels equipped with QR Code technology that are designed and produced in Iran and thus are not costly. Nevertheless, these two plans do not provide product owners with any special added value services and what matters is only product authentication; therefore, the fixed price is low.

In order to design service revenue models, a service provision strategy was developed and finally two types of service provision strategies were selected based on which the business model was designed and developed. Advantages and disadvantages of the proposed business models with sales strategy are depicted in Table 2 and Table 3.

As already stated, following the legal and tax barriers, the project team began to develop service revenue models. These models are more complicated because they are different from the selling nature of the authentication database, so it will be more difficult to implement it and make a contract

Table 4 and Table 5 describe each of the above models and determine their advantages and disadvantages.

Table 2.

Advantages of authentication database with a sales revenue model

1st: Selling by receiving a post-dated cheque from the product owner	2nd: Receiving from the product owner for the first authenticity check	3rd: Receiving from the customer for the first authenticity check	4th: Receiving from the product owner for the first authenticity check - settlement at the end of the contract (combination of the first and the second models)	5th: Partnership with the product owner in receiving the cost from the end customer
1. Ease and convenience of the contract 2. Independence of receiving money from selling or not selling 3. Independence of the contract from the financial system and the sales of the product owner 4. Settlement at the end of the contract, not at the beginning 5. Attracting more end customers due to receiving a valuable free service	1. Receiving a large number of labels and settlement in installments and after selling the product 2. Reducing the product owner's risk 3. The product owner's willingness due to not paying in a lump sum at the time of making the contract 4. More precise communication with customers compared to the first method 5. Increased quality of product information 6. Attracting more end customers due to receiving a valuable free service 7. Providing assistance to the product owner to identify counterfeit products and monitor the stores performance	1. The product owner and the store's willingness to use this method 2. Independent from the financial and sales systems as well as warehouse of the product owner 3. Receiving more precise customer information (e.g., buyer name, place, and time) 4. Increased quality of information 5. The authentication database playing the role of an ownership document 6. Eliminating the product owner's risk of not selling the products (label) 7. The possibility of the buyer authentication only through this method	1. Seller's more precision in entering information compared to the first method 2. More realistic ceilings for orders 3. The seller's higher level of willingness to change the "sold" mode due to the seller's discount label 4. Increased quality of information 5. Money-back guarantee 6. More precise communication with customers 7. Attracting more end customers due to receiving a valuable free service	1. The cost of entering information is free for the product owner 2. The owner of the product tries harder to persuade customers to use the system 3. The product owner and the store welcome this method 4. Independent from the financial and sales systems as well as warehouse of the product owner 5. Receiving more precise customer information (e.g., buyer name, place, and time) 6. Increased quality of product information 7. The authentication database playing the role of an ownership document 8. The risk of not selling the product (label) is only for the authentication database. The product owner has no risk. 9. Buyer's authenticity verification via this method

Table 3.

Disadvantages of authentication database with a sales revenue model

1st: Selling by receiving a post-dated check from the product owner	2nd: Receiving from the product owner for the first authenticity check	3rd: Receiving from the customer for the first authenticity check	4th: Receiving from the product owner for the first authenticity check - settlement at the end of the contract (combination of the first and the second models)	5th: Partnership with the product owner in receiving the cost from the end customer
1. The product owner showing less willingness at the beginning of running the authentication database due to its unpopularity 2. Low utility in case of selling less than the amount considered in the contract 3. Lack of communication with the end customers of the chain 4. Not sharing sales risks with the product owner 5. Low quality of information given to the end customer 6. The product owner willing to order few labels in multiple orders and increasing the overhead expenses 7. Failure to detect fraud occurred due to not changing the label status to "sold"	1. Complexity of implementation and entanglement with financial and sales systems in the store 2. The product owner's worry about sharing financial and sales information 3. Less willingness from the stores which are not exclusive representatives of the product owner 4. Lack of willingness in stores to change the "sold mode" due to its consequent charges 5. Ordering too many labels (it is necessary to specify a ceiling in the initial contract) 6. Increased complexity in the software system due to the need to manage sold products' price tag in each store 7. Failure to detect fraud occurred due to not changing the label status to "sold"	1. Product authenticity check by a low percentage of customers 2. A need to increase the price of the label due to authenticity check by a small proportion of customers 3. Distortion of information comprehensiveness due to authenticity check by a small proportion of customers 4. Too many orders because the label is free (a ceiling needs to be set) 5. A need to define information and value-added services to motivate the end customer (guarantee, lottery, and after-sales services)	1. Complexity of implementation and entanglement with financial and sales systems in the store 2. The product owner's worry about sharing financial and sales information 3. Less willingness from the stores which are not exclusive representatives of the product owner 4. Increased complexity in the software system due to the need to manage sold products' price tag in each store 5. Failure to detect fraud occurred due to not changing the label status to "sold"	1. Product authenticity check by a higher percentage of customers compared to the third method 2. Increased price of the authentication database service for the end customer due to partnership with the product owner

Table 4.

Advantages of an authentication database with a service revenue model

1st: Activating label services with the first tap	2nd: providing services per tap	3rd: Providing services for the customer's first tap	4th: Sales and service provision contract	5th: Annual subscription (gold, silver, bronze)	6th: Establishment of a new enterprise by specifying the possibility to sell in the Articles of Association
1. Appropriate profit 2. Low investment risk for the enterprise 3. No need to change current system processes 4. Easy execution of sales process	1. Product owners' higher level of willingness to buy labels due to low price 2. Product owners' reduced risk of customers not welcoming the product 3. Easy execution of sales process	1. Welcoming product owners and sellers 2. Getting more precise customer information 3. Eliminating the risk of not selling labeled Products for the product owners	1. Covering the initial cost for all types of labels 2. Profitable and low-risk model for any amount of ordering 3. A higher level of alignment with the business reality and the processes of the authentication database	1. Easy to create a free one month offer and the like for the product owners 2. The model is provided as a service with no sales (similar to broadband or Internet service provider models) 3. A well-known and standard plan for providing services 4. Contract's independence from the system 5. an average level of risk for the product owners and the authentication database regarding the amount of income and customers' acceptance	Non-compliance with not selling limitations (in accordance with the Articles of Association) Higher level of efficacy and greater focus on services Introducing other ancillary services such as entering information for the product owners in the new enterprise's missions Transparency of financial contracts Lower premium and tax costs

Table 5.

Disadvantages of an authentication database with a sales revenue model

1st: Activating label services with the first tap	2nd: providing services per tap	3rd: Providing services for the customer's first tap	4th: Sales and service provision contract	5th: Annual subscription (gold, silver, bronze)	6th: Establishment of a new enterprise by specifying the possibility to sell in the Articles of Association
1. The customer's suspicion to the sales contract 2. All labels must be offered at the same price or a separate contract is required based on the type of label 3. Mandatory first tap by the product owner or the seller 4. The system must be able to separate the seller's taps (in order to activate) from those of the customer	1. A need to introduce more value-added services such as guarantee and persuade customers to tap more often 2. Inadequate profit: while assuming 40% tap on the product, the ratio of the break-even point of each tap should be 37500 Rials compared to the first model	1. A need to change the model when the system is pervasive due to unprofitability (because of the existence of the authentication database label, sellers and product owners are less likely to encourage customers to tap) 2. Increased sales prices because the product authentication is done by a low percentage of customers	1. False assumption of selling instead of providing services 2. Product owners less willingness to pay in advance if they are not provided with financial facilities 3. Less welcoming product owners due to increased risk of customers' acceptance	1. If the number of labels is specified before the contract, the model is service-based and not transactional 2. The way to pay on the website and the way to recharge requires arrangements in the authentication database 3. Low flexibility for label type and the number of orders	1. A need for investment and initial expenditure 2. Existence of legal restrictions for establishing a new enterprise

Authentication business model

After determining the authentication database service revenue strategy and specifying the business model canvas components based on the Osterwalder and Pigneur's model, the authentication database business model canvas is designed and presented. It is worth mentioning that the authentication database canvas is prepared with a focus on service provision and in three forms including the authentication database general model which contains common components, the second model of service revenue that is "service provision per tap", as well as the fifth model of service revenue that is "annual subscription strategies (Bronze, Silver, and Gold)".

- **General Business Model Canvas**

The authentication database business is in general terms similar to that of other authentication databases such as Shabnam and Esalat-e Salamat. In the business model designation and development, the points outlined in the meetings with the craft enterprises as well as those obtained through market research were taken into account and are as follows:

▪ As for the revenue stream, a model which is initially free (for the product owners and not end customers) and is later monetized is doomed to fail and the brand collapses.

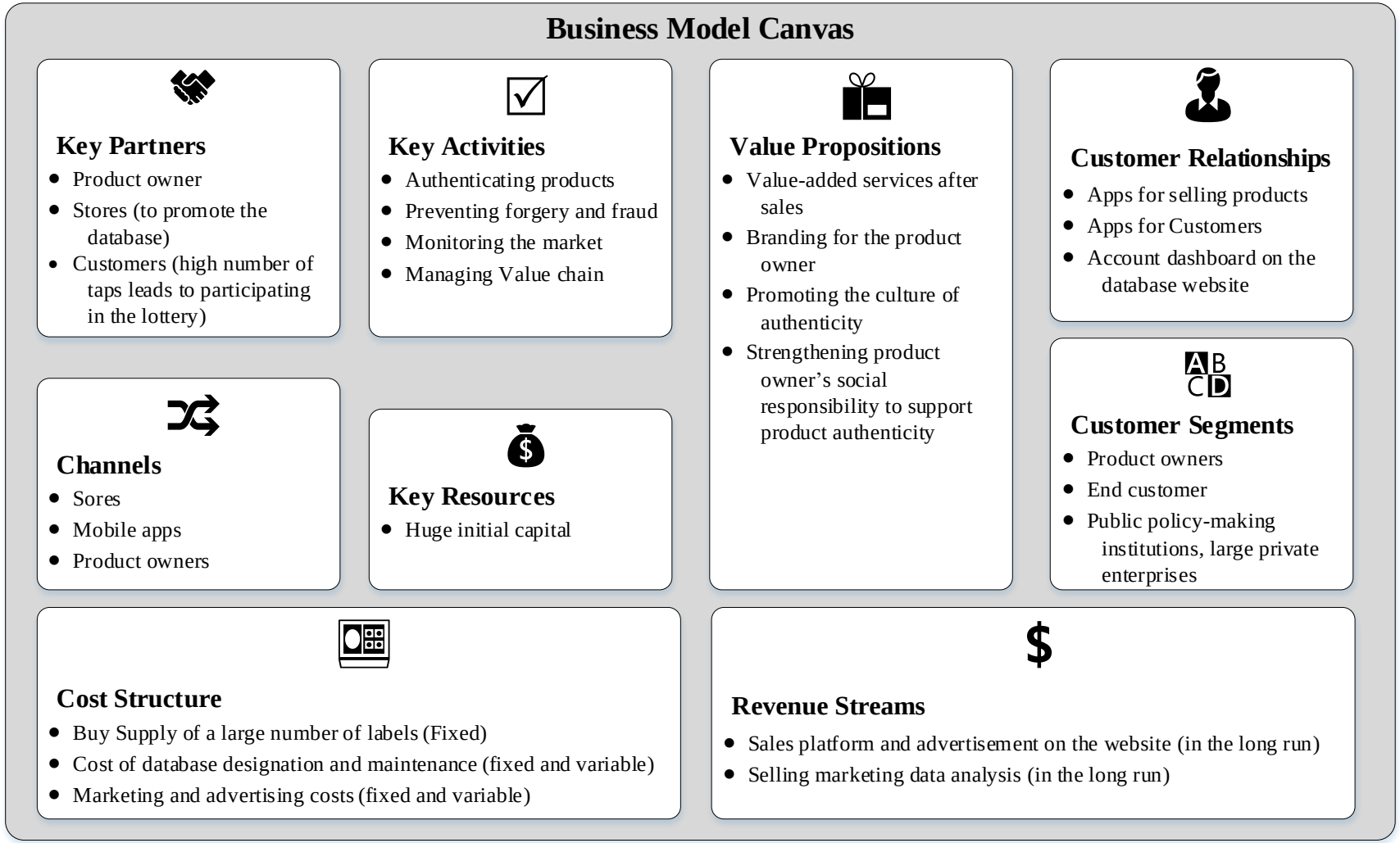
▪ Due to the traditional nature of most sales systems in Iran, metadata analysis might be profitable in the long run. Therefore, other methods should also be adopted, such as turning the authentication database into a national gateway through which everyone carries out a product authenticity check. Hence, it is possible to earn income both through advertising and online shopping. In other words, instead of buying in person, the customer can buy online from the authentication database. This way, the authentication database can become the most important gateway for buying products and checking their authenticity in Iran, because products information and prices are readily available and through which the products are provided by the owner and delivered to the customer.

▪ In the future, the authentication database may seek to make the best use of this position and its huge volume of end customers (domestic and foreign) in an attempt to do market research for different industries and to find niche markets. Therefore, short-term profitability goals are recommended to be avoided. Instead, branding and getting recognized by the product owners and the target customers are recommended to be taken seriously.

Overall, a general overview of the authentication database business model canvas is illustrated in Figure 2.

Figure 2.

General Business Model Canvas



This revenue model is more valuable compared to other models because the product owner does not pay much and is further motivated to enter into a contract. The advantages and disadvantages of this model is shown in Table 6.

Table 6.

Advantages and disadvantages of "service provision per tap" revenue strategy

"Service provision per tap" strategy	
Advantages	**Disadvantages**
1. Product owners' higher level of willingness to buy the label due to the fixed and the initial cost 2. Reduced risk of less acceptance customers for the product owner 3. Easy implementation of service provision process	1. A need to define many added value services such as guarantee and to persuade customers to tap again and again 2. Inadequate profit: Inadequate profit: while assuming 40% tap on the product, the ratio of the break-even point of each tap, compared to the first model (with a price of 15000 Rials), should be 37500 Rials 3. A tap after the contract and failure to receive money and consequent losses for the database business 4. Complexity in concluding the contract
"Annual subscription" strategy	
Advantages	**Disadvantages**
1. It is easy to provide the product owners with a promotional offer for free services in case of time extension 2. The model provides services and no sales are occurring (just like broadband or Internet service provider models) 3. A well-known and standard plan for service provision 4. Independence of the contract from authentication processes 5. Reduced risk of customers' acceptance for the authentication database 6. Higher profits for the database business	1. If the number of labels is specified before the contract, the model is service-based and not transactional 2. The way to pay on the website and the way to recharge necessitates creating a dashboard for the product owner in the authentication database 3. Low flexibility regarding the type of label and the number of orders both for a specific product owner and after the contract 4. More diverse contracts both in one industry and also among different industries

- **Annual subscription strategies (Bronze, Silver, and Gold)**

The current model differs from the previous model in terms of revenue generation and operations. In this model, the product owners, for whom the authenticity is of great importance, are addressed. Moreover, Customer Relationship Management (CRM) and marketing management have the next priority (for the product owners who want to find customers). Table 6 represents the pros and cons of these two revenue strategies.

Following an exploration of the revenue strategy and specification of its pros and cons, the business model canvas was designed and presented in Figure 3 and Figure 4

.Figure 3.

Business Model Canvas Based on "Service provision per tap" Revenue Strategy

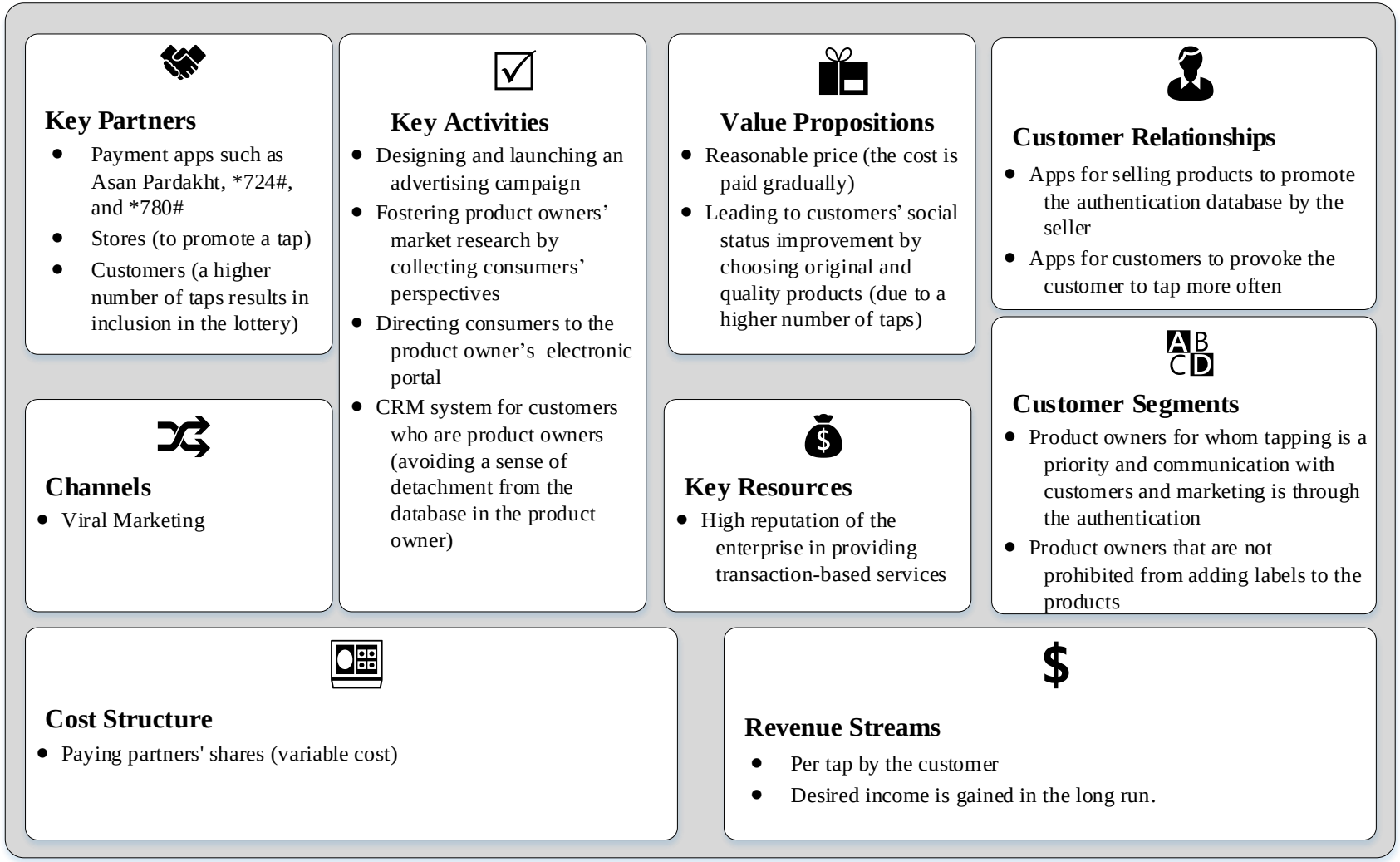
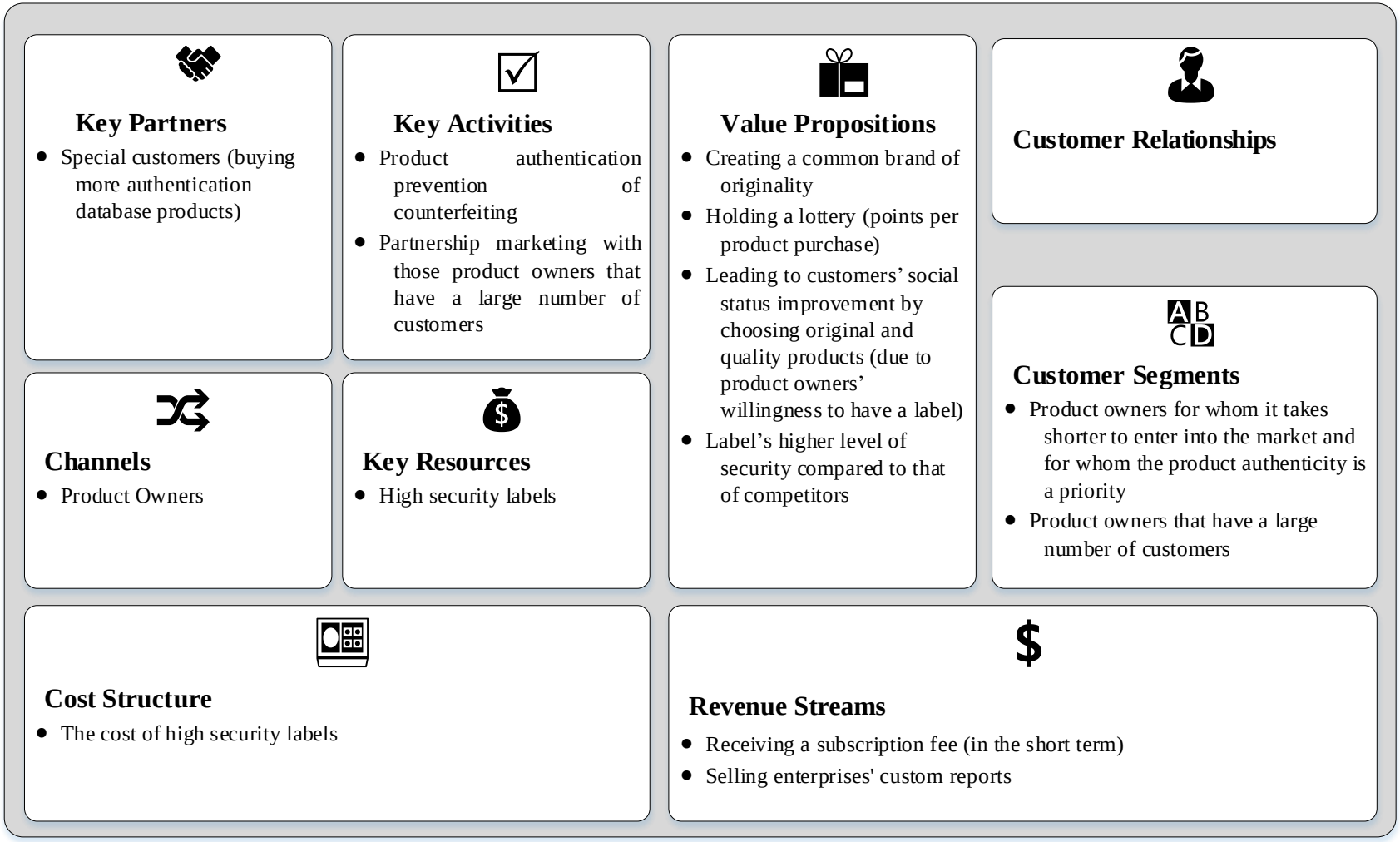


Figure 4.

Business Model Canvas Based on "Annual subscription (Bronze, Silver, and Gold scheme)" Revenue Strategy



Managerial Insights

The following managerial insights can be excavated.

▪ Targeted Service Differentiation Enhances Value Proposition Managers should recognize that not all product owners require or desire authentication services. The business model must prioritize selective service provision, focusing on owners of original, high-value products who actively seek authenticity verification. This segmentation ensures that resources are allocated to customers who derive the most value, enhancing satisfaction and retention.

▪ Customer-Centric Design Drives Engagement In the "service provision per tap" model, the end customer becomes the focal point. Managers should ensure that product labels include comprehensive information—such as guarantees, after-sales services, and related offerings—to increase tap rates and customer interaction. This approach strengthens brand trust and encourages repeat engagement.

▪ Strategic Partnerships Boost Adoption Collaborations with digital platforms like Rubika can significantly enhance visibility and usage in tap-based models. Managers should actively pursue partnerships that align with the business model's engagement strategy. However, in subscription-based models, such partnerships are less critical, allowing for more streamlined operations.

▪ Data-Driven Insights Sustain Long-Term Relationships Regardless of the revenue model, the authentication database must deliver actionable marketing intelligence to product owners. Providing location-based customer data and usage analytics can inform marketing strategies and product positioning, increasing the likelihood of contract renewal and long-term collaboration.

▪ Voluntary Adoption Encourages Trust and Legitimacy Past government-led models like Shabnam and Esalat-e Salamat suffered from mandatory enforcement, which alienated product owners. Managers should ensure that participation in the authentication system remains voluntary, fostering trust, ownership, and organic adoption among stakeholders.

▪ Awareness Campaigns Precede Profitability For widespread adoption, comprehensive advertising and awareness efforts must precede monetization strategies. Managers should prioritize building brand recognition and educating stakeholders about the benefits of authentication services before focusing on profitability.

▪ Positioning the Database as a National Gateway With consistent delivery of value-added services and strategic outreach, the authentication database has the potential to evolve into a national platform for product verification and market intelligence. Managers should align long-term goals with this vision, investing in infrastructure, scalability, and cross-sector integration.

Concluding Remarks

This research was conducted in an attempt to design a business model for NFC technology with the aim of developing foreign markets for original products in the form of authentication database services. After an in-depth description of Osterwalder's business model and selecting the business model canvas, the service and sales revenue models of the authentication database business were explained in detail. In accordance with service revenue model, two types of business models including "service provision per tap" and "annual subscription

strategies (Bronze, Silver, and Gold)" were proposed.

- The above strategy is that the authentication database provides original products owners with special services and not all product owners have the right to use the authentication database. This model is more welcomed by a proportion of the market that wants to present the authenticity of their products. In addition, in this model, the product owner is our end customer and the product authenticity should be prioritized over marketing research. By the way, product owners should be provided with different reports so that they can make appropriate decisions about their marketing activities.
- Regarding the "service provision per tap" strategy, the customer is important and the originality of the product is important to the customer. In the fifth model, the product owner who is important gives priority to product marketing. In addition, in this model, the customer is our end customer. Therefore, the information about the guarantee, after-sales services, as well as ancillary products and services should be provided on the label so as to increase the tap rate.
- In the "service provision per tap" model, the presence of business partners such as Rubika can greatly assist in increasing the tap rate but in the "annual subscription strategies (Bronze, Silver, and Gold)" model, considering that the income is generated through subscriptions, the presence of these partners is not necessary.
- In both models, the authentication database should supply product owners with useful marketing-related information which can to a great extent lead to the continuation of the contract and can turn the authentication database into a national gateway.
- One of the biggest weaknesses of the Shabnam and Esalat-e Salamat models was that they were government-owned and that the product owners would consider using their labels as obligatory. Therefore, in both models, it is recommended that the product owners have the liberty to use or not to use these labels without an enforcement by governmental institutions.
- In both models, the main goal should be the widespread use of the authentication database and appropriate strategies should be adopted for comprehensive advertisement, and then the profitability of the database should be the next priority.

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RESEARCH ARTICLE **Open Access**

Adoption of Soft Systems Methodology (SSM) to Develop an Efficiency Assessment Framework through DEA for Gas-Fired Power Plants in Southern Iraq

Kamil Yaseen Sharrad [1], Payam Shojaei [2*], Abolghasem Ebrahimi [3], Kazem Askarifar [4]

Abstract
Given the growing demand for electricity in Iraq and the significant contribution of gas-fired power plants to electricity generation, evaluating and improving the efficiency of these units from economic, environmental, and social perspectives is an imperative. This study aims to develop an integrated framework for identifying inputs and outputs for employing Data Envelopment Analysis (DEA) to assess the performance of gas-fired power plants in southern Iraq. To this end, Soft Systems Methodology (SSM) was employed to identify and structure problematic factors and challenges through expert interviews. The challenges of electricity generation and influencing factors were structured as inputs and outputs. The findings revealed that the inputs and outputs of gas-fired power plants in Iraq can be defined within seven subsystems: economic, environmental, supply, human resources, technology and infrastructure, social, and managerial. The integration of SSM and DEA provides an effective framework for multifaceted performance analysis, enabling root definitions and conceptual modeling that support evidence-based policymaking, efficient resource allocation, and strategic planning for structural reform and transition toward sustainable energy within Iraq's power sector.

Keywords: *Data Envelopment Analysis, Soft Systems Methodology, Gas-fired power plants, Iraq's power sector, Performance evaluation*

Introduction

In today's world, energy is recognized as one of the fundamental pillars of economic, environmental, social, and industrial development across nations. Population growth, urban expansion, industrialization, and rising living standards in many developing countries—particularly in the Middle East—have led to a continuous increase in energy demand (Chen et al., 2022; Yumashev et al., 2020). Among various forms of energy, electricity is especially vital; it not only facilitates daily life but also underpins production, transportation, agriculture, education, and numerous other economic activities (Mahfoudh & Amar, 2020; EIA, 2023). According to the International Energy Agency's 2024 report, Middle Eastern countries possess a significant share of the world's energy resources, yet continue to face structural challenges in energy efficiency and management. Iraq, as one of the region's major oil and gas producers, exemplifies this contradiction; despite vast reserves, its

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electricity sector struggles with a pronounced mismatch between supply and demand. In 2023, Iraq's maximum electricity generation capacity was approximately 27.4 gigawatts, while peak demand exceeded 35 gigawatts (IEA, 2024). This considerable gap has led to widespread outages, an overreliance on imported electricity, and extensive use of non-standard generators.

Studies indicate that over 98% of electricity generated in Iraq is sourced from fossil fuels—a figure significantly higher than the global average—resulting in elevated greenhouse gas emissions and increased environmental pressure (Ember, 2024). Concurrently, Iraq imports more than 30% of its annual electricity consumption from neighboring countries such as Iran, Turkey, and Jordan, reflecting insufficient domestic infrastructure and the low operational efficiency of its power plants. Moreover, energy losses within Iraq's electricity network are estimated to be extremely high. According to World Bank statistics, nearly 50% of the electricity produced either never reaches the billing stage or remains unpaid by consumers. This situation stems from obsolete equipment, poor distribution management, and the absence of effective pricing policies (World Bank, 2023). Therefore, enhancing the efficiency of power plants and optimizing electricity production have become strategic priorities for the Iraqi government and international organizations. In response to these challenges, the application of quantitative and analytical methods for evaluating and analyzing performance in the power sector appears essential. Data Envelopment Analysis (DEA) is among the most well-established non-parametric tools used to assess the relative efficiency of decision-making units based on multiple input and output variables (Xu et al., 2023). DEA is a mathematical programming technique grounded in a positivist approach that evaluates the relative efficiency of decision-making units using input and output data. This method can effectively compare the performance of various power plants and identify inefficient units. A review of the theoretical literature related to DEA in the energy domain reveals that the model has been applied to assess the performance of thermal, gas-fired, nuclear, and even renewable power plants. The study by Bampatsou, Papadopoulos, and Zervas (2013) on nuclear power plants in Europe; the research by Munisamy and Arabi (2015) on thermal power plants in Iran; Xiao, Tian, and Ren's (2022) decade-long investigation of power plants in China; and the work by Rodríguez-Lozano and Cifuentes-Yate (2021) on electricity generation in the Middle East are notable examples of studies that have employed Data Envelopment Analysis (DEA) in the assessment of power generation efficiency. These investigations collectively demonstrate DEA's capability to identify inefficiencies in energy resource utilization and to assist decision-makers in mapping out performance improvement paths. The findings highlight the necessity of using the DEA model to evaluate gas-fired power plants in a country like Iraq, where infrastructure has been severely impacted in recent years and energy productivity remains under intense pressure from rising demand.

However, quantitative analysis alone is insufficient for comprehending the human, structural, and institutional dimensions underlying inefficiency. Additionally, the selection of inputs and outputs for efficiency assessment is highly influenced by the judgment of decision-makers, which can

significantly affect the outcomes. In this context, Soft Systems Methodology (SSM) serves as a valuable qualitative tool for uncovering systemic and societal roots of inefficiency-related problems (Checkland & Scholes, 1999). This approach the ability to be used in identifying indicators, factors, inputs, and outputs and different stakeholders' views through the system structure it follows (Karame et al., 2020; Valafar et al., 2020). At first glance, Soft Systems Methodology (SSM) and Data Envelopment Analysis (DEA) may appear to share limited commonalities—given that SSM is a conceptual framework grounded in subjective epistemology (Mingers, 2009), whereas DEA is a positivist and objectively oriented method. Nevertheless, underlying similarities do exist between these two approaches. Specifically, the transformation process from inputs to outputs serves as the central link in this integrated framework. SSM offers the capacity to provide alternative perspectives on the nature of decision-making units, particularly when considering diverse input and output configurations. In this study, SSM is introduced as a valuable approach for structuring decision-making units and defining relevant inputs and outputs for assessing the efficiency of Iraq's gas-fired power plants using DEA. Through root definition (RD) and conceptual modeling inherent in SSM, a novel pathway is proposed to enhance problem structuring within the DEA framework. Accordingly, this study designs and implements an integrated analytical framework based on Soft Systems Methodology (SSM) to evaluate the efficiency of gas-fired power plants in southern Iraq. Within this framework, SSM is employed to identify key structural and human-related factors contributing to inefficiency, while DEA is applied to assess the relative performance of the power plants using defined inputs and outputs. This approach facilitates the development of improvement strategies both at the technical and systemic levels. Given the growing importance of efficiency in the power sector and its direct impact on economic growth, social equity, and environmental sustainability, such research can play a pivotal role in advancing sustainable development, effective policymaking, and strategic energy planning in Iraq and other developing countries in the region.

Theoretical Framework

Importance of Electricity in Iraq Development

Electricity is considered one of the most critical infrastructures for economic and industrial growth. As a secondary form of energy, electricity can be converted into other energy types and plays a key role across all economic sectors, including agriculture, industry, transportation, services, and education (Dong et al., 2024). Nations seeking greater productivity, social welfare, and international competitiveness are compelled to develop sustainable energy supply systems—particularly in the electricity sector (Adom, 2024). Globally, electricity consumption has risen markedly in recent decades. For instance, in 2019, global electricity usage surpassed 25,000 terawatt-hours (IEA, 2024). Meanwhile, the structure of electricity generation has undergone significant transformation; although fossil fuels continue to account for the majority share (around 62%) of global production, the share of renewable energy sources has grown to approximately 27% (Hassan et al., 2024), while nuclear energy covers about 10% of

global electricity output. These figures reflect a gradual global transition from polluting energy sources to cleaner alternatives. Accordingly, with the continued increase in electricity demand—especially in developing countries—precise planning for optimal and sustainable electricity generation has become more critical than ever (Belaid, 2023).

Iraq, as a developing country endowed with vast oil and gas resources, faces serious challenges in electricity generation. Infrastructure damage due to repeated wars, inefficient management, high transmission losses, and reliance on imports are among the major obstacles confronting the country (Mills & Salman, 2020). Iraq's first electricity grid was established in Baghdad in 1917, yet during the Gulf War (1991), over 90% of the grid was destroyed. Although more than 68 new power plants—comprising thermal, gas-fired, and hydroelectric units—have been built since 2003, operational capacity still falls short of meeting the growing demand from population and industrial expansion (Nijkamp et al., 2025; World Bank, 2023). Iraq's electricity is primarily generated from three types of power plants (Worldometers, 2024; IEA, 2024):

- Thermal power plants: Seven active units located in provinces such as Baghdad, Nineveh, and Babylon, with an approximate combined capacity of 6,900 megawatts, operating on fossil fuels.
- Hydroelectric power plants: Eight units based at dams such as Mosul and Samarra with a total capacity of 2,583 megawatts. Their performance is variable and constrained due to declining rainfall.
- Gas-fired power plants: 26 operational stations with a collective capacity exceeding 14,550 megawatts, constituting the primary source of electricity production in Iraq. However, due to technical issues and gas shortages, these plants are not fully utilized.

Despite increased installed capacity, Iraq continues to face a shortfall of 10 to 15 gigawatts during peak consumption periods, and its reliance on electricity imports places considerable strain on the national economy (Ember, 2024). In addition to this issue, high energy losses, the absence of realistic pricing mechanisms, and inefficiencies in management structures are key factors contributing to low productivity. Under such conditions, the use of quantitative and analytical methods—such as Data Envelopment Analysis (DEA)—offers a viable strategy for enhancing efficiency, reducing resource waste, and improving policy decision-making. However, measuring efficiency in the energy sector is inherently challenging and necessitates models that appropriately account for environmental variables such as energy prices, technological capabilities, firm size, and other micro-level factors (Arabshahi Delouee et al., 2020; Li & Tao, 2017; Rahman et al., 2023). Energy efficiency in the electricity industry refers to the generation of electricity with minimal energy consumption and pollutant emissions. This metric considers not only the ratio of energy services to energy inputs but is also influenced by factors such as technology, industrial structure, energy pricing, and consumption patterns (Fu et al., 2023). Therefore, it becomes essential to identify the key structural and human-related factors driving inefficiency and to determine appropriate inputs and outputs for evaluating

the relative performance of electricity generation. Through this approach, performance improvement strategies can be proposed at both technical and systemic levels.

Literature Review

In recent years, numerous studies have been conducted to evaluate energy efficiency in the electricity sector through the application of Data Envelopment Analysis (DEA). Among domestic investigations, Mahmood et al. (2017), through an assessment of ISO 50001 standards at Iraq's Ministry of Electricity, demonstrated that implementation of the standard led to improved performance in power generation units. According to the majority of respondents, its application was both straightforward and effective. In continuation of this research trajectory, Nadhum and Erzaij (2020) examined barriers to electricity generation projects in Iraq and identified economic and financial variables as the most influential factors in this domain. Their mathematical model contributed to prioritization strategies for project design in the country. In other studies, Abed et al. (2020), focusing on energy optimization through smart grids and solar energy in Iraq, found that modern technologies can significantly reduce energy losses. Altai et al. (2022), through a comprehensive analysis of Iraq's electricity sector, emphasized the necessity for structural reforms and proposed measures aimed at improving billing systems, enhancing private sector participation, and increasing overall efficiency.

Extensive research has been conducted in recent years on the efficiency of the electricity sector and the application of Data Envelopment Analysis (DEA). Ervural et al. (2018) applied a two-stage DEA model to thermal power plants with a focus on sustainability. A systematic review by Mohd Chachuli et al. (2020) further shows that Data Envelopment Analysis (DEA) has been extensively used in evaluating the performance of renewable energy sources—such as solar, wind, and biomass—and that the methodological evolution of DEA in recent years has prominently featured dynamic and hybrid models. Guang et al. (2022), through an analysis of electricity consumption trends from 2007 to 2019, attributed the decline in consumption rates to changes in industrial structure and improvements in energy efficiency. They projected that, if this trajectory continues, electricity consumption will become increasingly sustainable in the future. Studies by Mamipour and Najafzadeh (2016), Radsar et al. (2021), and Khosravi et al. (2022), using network DEA approaches and incorporating undesirable outputs such as energy losses and pollutant emissions, have underscored the critical role of power plants, regional electricity companies, and distribution firms in shaping the overall efficiency of Iran's electricity industry. Patyal et al. (2023) conducted an empirical study evaluating the operational performance of 48 Indian electricity distribution companies. Their research employed a hybrid methodology integrating Data Envelopment Analysis (DEA) and Multi-Attribute Decision Making (MADM) to distinguish between efficient and inefficient DMUs. The study by Esfandiari and Saati (2024) introduced a hybrid two-stage DEA model to enable more precise techno-economic analysis of thermal power plants. Wang et al. (2024), in their evaluation of Total Factor Energy Efficiency (TFEE) across ten major energy-consuming countries, found that developed nations such as the United States and Germany ranked

highest in energy efficiency, while China and India exhibited relatively weaker performance. Their analysis further highlighted the significant influence of per capita GDP and energy consumption structure in determining efficiency levels. Wei and Zhao (2024) developed a three-stage DEA model to assess carbon emission reduction performance across 30 Chinese provinces, municipalities, and autonomous regions. This methodological framework effectively controlled for competitive dynamics and external environmental factors, enhancing the robustness of their efficiency measurements. Sufia et al. (2025) applied an innovative three-stage DEA approach to analyze the operational efficiency of Indian electricity distribution utilities from 2016–17 to 2019–20. Their results underscored the critical role of service quality parameters in operational efficiency evaluations. Yadava et al. (2025) performed a benchmarking analysis of Indian electricity distribution companies, revealing that transient inefficiency contributed more significantly to overall inefficiency than persistent inefficiency. Zhang and Zhang (2025) introduced an extended mixed-network DEA framework designed to differentiate between fossil energy power generation (FEPG) and non-fossil energy power generation (NFPG). Their model simultaneously addressed generation diversity, resource sharing, input optimization, and undesirable outputs, offering a comprehensive analytical tool for energy efficiency assessment.

These studies consistently identified the production stage as having the greatest impact on aggregate productivity, and applied both cross-sectional and panel data to analyze temporal trends and performance disparities across units. Additionally, several recent studies have emphasized the crucial role of Soft Systems Methodology (SSM) in identifying conceptual structures and deriving input/output indicators for DEA within the electricity industry. Susanty et al. (2022) employed SSM to develop a structured framework for analyzing the efficiency of a power distribution company.

As evidenced by the review of empirical literature, various studies across different countries—including Iraq—have examined electricity generation efficiency from diverse perspectives. However, analysis of these investigations reveals that most research efforts have focused predominantly on evaluating and measuring efficiency within power plants and electricity production companies, while the development of a suitable model to enhance electricity generation efficiency has yet to become a central focus for researchers. The use of Soft Systems Methodology (SSM), which is grounded in systems thinking, meaning, self-reflection, interpretation, human experience, and learning—alongside tools such as CATWOE and PQR analysis—can provide a rich and nuanced understanding of how inputs are transformed into outputs within the electricity generation system of gas-fired power plants. This approach offers a structured means to accommodate diverse viewpoints and development interests, ultimately supporting efficiency assessment through the identification of appropriate input and output variables.

Methodology

This study seeks to develop a model for evaluating electricity generation efficiency in gas-fired power plants located in southern Iraq, aiming to apply its findings to enhance productivity and reduce inefficiencies within

these facilities. The research utilizes Soft Systems Methodology (SSM) to identify the input and output variables associated with the operational performance of gas-fired power stations (Mingers et al., 2009; Susanty et al., 2022). To achieve this, the study combines semi-structured expert interviews, a systematic review of theoretical literature, and consultations with power industry professionals to extract key input and output variables. The research sample consists of specialists from power plants operated under the Southern Iraq General Electricity Production Company, including the Old Khor Al-Zubair, New Khor Al-Zubair, Shuaiba, Nasiriyah, Najibiya, Shatt Al-Basra, Amarah, and Rumaila gas-fired power stations. Table 1 presents the profile of the participating experts. Purposeful judgmental sampling was employed in this study, and data collection instruments included semi-structured interview protocols designed to support the implementation steps of Soft Systems Methodology (SSM). Rooted in systems thinking, SSM offers an interpretive and human-centered approach for addressing complex organizational issues. In this research, SSM was applied to identify appropriate input and output variables for the DEA model through stakeholder interviews and problem environment analysis.

Table 1.
Expert Profile

Affiliation	Academic Degree	Position	Years as Expert
Southern Region Power Production Co.	Bachelor's	Electrical Engineer	22
Nasiriyah Power Generation Unit	Bachelor's	Control Engineer	22
Nasiriyah Power Generation Unit	Bachelor's	Electrical Engineer	22
Nasiriyah Power Generation Unit	Bachelor's	Mechanical Engineer	22
Samawah Power Plant	Bachelor's	Electrical Engineer	9
Samawah Power Plant	Bachelor's	Electrical Engineer	16
Samawah Power Plant	Bachelor's	Mechanical Engineer	6
Samawah Power Plant	Diploma	Technical Manager	20

Soft System Methodology (SSM)

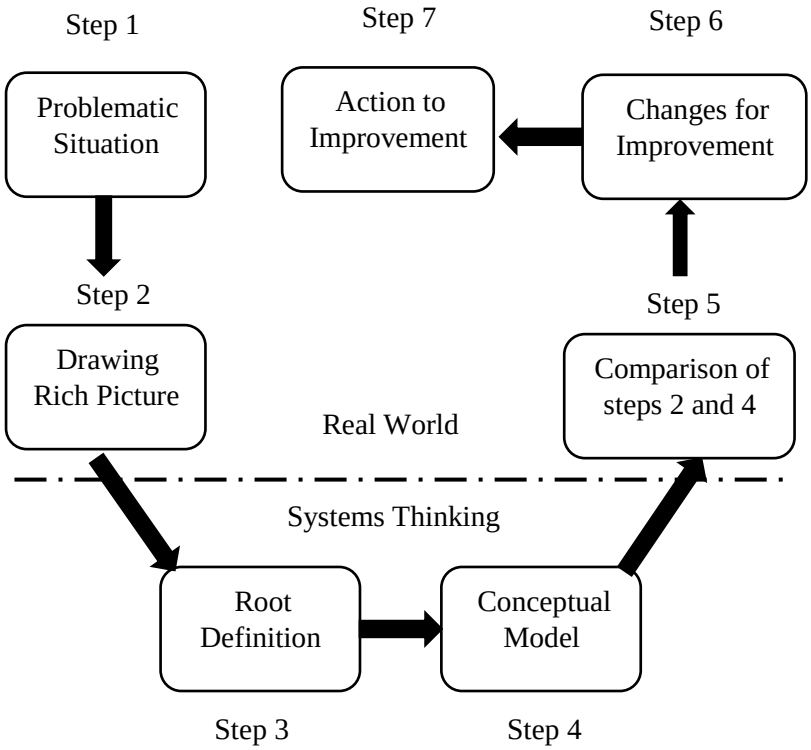
The implementation process of Soft Systems Methodology (SSM), as illustrated in Figure 1, comprises seven distinct stages. The first step involves exploring the problematic situation—an initial diagnostic inquiry into the issue environment. This phase includes sessions with managers, operational staff, and analysts to investigate current activities and work practices. It extends beyond identifying explicit problems by adopting a comprehensive and systematic approach to uncover hidden aspects, such as layers of systemic contradictions, conflicts, and constraints.

The second stage entails drawing a rich picture, whereby the analyst collects, categorizes, and synthesizes relevant information to produce a comprehensive depiction of the problematic context. The third step focuses on formulating root definitions, which determine the specific perspectives from which the issue should be understood. During this phase, subsystems related to the problem are identified and named—an essential process for modeling, as these names guide the development of system

representations. The formulation of root definitions enables analysts to define each organizational activity clearly and provides a coherent foundation for system modeling. It is a transitional process whereby existing processes, activities, and conditions are treated as inputs, refined through SSM, and subsequently transformed into structured outputs. Based on the derived root definitions, conceptual models are developed in the fourth stage to represent the system's ideal functioning. Conceptual model design refers to the development of a representation that explains the conditions of the problem situation. Typically, a separate conceptual model is created for each root definition, and following coordination, a consensus model is developed jointly by analysts and stakeholders. A conceptual model serves as a schematic of activities that illustrate what the systems—defined by the respective root definitions—are intended to do. At this stage, the goal is to construct a purpose-driven system model that identifies the necessary activities for achieving desirable outputs for system beneficiaries. The outputs of these two steps—combined with tools such as rich pictures, CATWOE analysis, and PQR analysis—enable the identification of systems, subsystems, and their corresponding inputs and outputs.

This method facilitates the incorporation of diverse perspectives and operational experiences from power plant stakeholders into the modeling process, guiding decision-making toward a holistic and participatory approach. Furthermore, the conceptual linkage between input, process, output, and efficiency evaluation in SSM aligns with the analytical framework of DEA, enabling synergy between the two methodologies (Checkland & Scholes, 1999; Mingers et al., 2009; Susanty et al., 2022). The final three stages of SSM—comparing the conceptual model to real-world conditions, defining improvement-oriented changes, and planning for change implementation—have limited relevance to the identification of inputs and outputs, which is the primary objective of this study within the DEA framework. These later steps may prove useful in enhancing system performance only after the mathematical DEA algorithms have been implemented.

Figure 1.
Process of Soft Systems Methodology (SSM)



Results

In this study, data analysis was conducted using a hybrid approach integrating Soft Systems Methodology (SSM) and Data Envelopment Analysis (DEA). The objective of this integration was to simultaneously leverage the advantages of systems thinking to gain a deeper understanding of the problem and to facilitate precise efficiency evaluation of selected gas-fired power plants in southern Iraq.

Soft Systems Methodology at the Macro-System Level

Step 1: Identifying and Addressing the Problematic Situation

The initial step in the SSM framework involves accurately identifying the problematic situation and developing a thorough understanding of the complex contextual conditions in which the issue occurs. In the present study—focused on assessing the efficiency of gas-fired power plants in southern Iraq—this step was carried out through semi-structured interviews with electricity sector experts, operational managers, power plant staff, and senior analysts from the Ministry of Electricity. Findings from this stage revealed that Iraq faces broad challenges across electricity supply, generation, and distribution, only some of which are attributable to technical or managerial deficiencies. Issues such as heavy reliance on imported electricity, inefficiencies in the financial structure of power plants, equipment obsolescence, misalignment between governmental policies and infrastructure needs, and the absence of a culture of efficient energy use collectively form a complex and deeply intertwined situation that renders electricity production in

southern Iraq a multifaceted and systemic problem.

From a techno-economic perspective, challenges such as limited financial resources for power plant development, insufficient budgets for maintenance and equipment renewal, delays in budget approval and allocation, and weak cost recovery mechanisms were identified. These issues have created production bottlenecks and reduced operational efficiency. On the environmental front, the use of heavy fuels, fuel leakage, and insufficient cooling water have contributed to extensive pollution and environmental degradation. Infrastructure-related challenges include the absence of advanced technologies, weak monitoring and smart control systems, and significant energy losses across transmission lines. In addition, the socio-human dimension of the problem encompasses uncontrolled population growth, informal electricity consumption in unauthorized settlements, employee distrust toward regulatory bodies, and the lack of specialized training and effective public awareness regarding energy consumption. Therefore, this initial step—grounded in qualitative data collection, stakeholder perception analysis, and multidimensional problem assessment—has established a robust foundation for the subsequent stages of SSM. Understanding this complex situation enables conceptual modeling, root definition formulation, and, ultimately, quantitative performance analysis via DEA. The defining characteristic of this phase is the acceptance of diverse viewpoints and the pursuit of understanding the 'subjective realities' of all stakeholders involved, recognizing that effective solutions to complex problems can only be designed through mutual understanding and multidimensional representation.

Step 2: Illustration of the Problematic Situation through Rich Pictures

In this stage, the findings from previous step are visually represented using a "rich picture" format. The purpose of constructing this visual illustration is to facilitate the conceptualization of the complex relationships among stakeholders, processes, resources, constraints, and conflicts inherent in the problematic situation. Rather than serving as a technical or mathematically precise diagram, the rich picture reflects the analyst’s subjective and systemic understanding of the issue—seeking to express complexity in a simplified and comprehensible visual language. Figure 2 depicts the rich picture of gas-fired electricity generation plants.

Figure 2.
Rich picture of gas-fired electricity generation plants

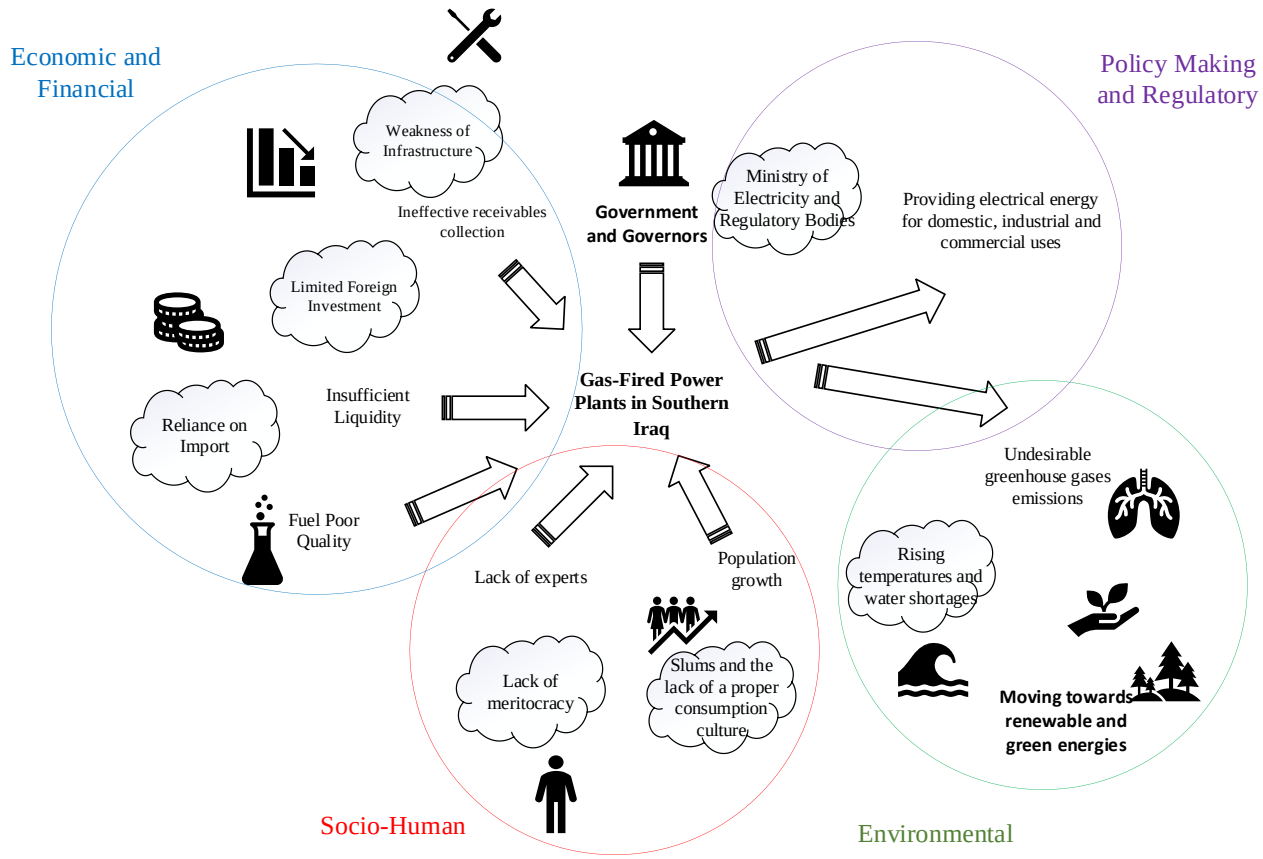


Figure 2 presents a conceptual model of the multidimensional challenges facing gas-fired power plants in Iraq, categorized into four primary domains: economic-financial, socio-human, policy and regulatory, and environmental. Within the economic dimension, factors such as aging infrastructure, limited foreign investment, dependence on electricity imports, and inadequate financial allocation have undermined the productivity of these plants. In the human dimension, shortages of skilled personnel, weak meritocracy, and inefficient energy consumption habits exert additional pressure on the grid. From a policy perspective, deficient governmental oversight, land acquisition issues, and unequal electricity distribution constitute major obstacles. Environmentally, greenhouse gas emissions, rising temperatures, and pollution underscore the urgency of transitioning to cleaner energy sources. This visual model highlights the necessity of adopting a systemic and integrated approach to improve the performance of Iraq's gas-fired electricity generation infrastructure.

Step 3: Development of Root Definition

To formulate the root definition—a core component of Soft Systems Methodology (SSM)—the CATWOE technique was employed. Root definitions may vary depending on differing worldviews; however, they must align with the decision-maker's perspective regarding the problem. In this study, CATWOE components were identified

for gas-fired electricity generation plants as a unified system, leading to the articulation of a root definition. Table 2 presents the CATWOE elements for gas-fired power plants in Iraq.

Table 2.

CATWOE Elements for Gas-Fired Power Plants in Iraq

CATWOE Component	Variable Description
Customers (C)	Electricity transmission companies; Iraqi citizens (household consumers), factories (industrial users), and all commercial establishments (commercial users)
Actors (A)	Gas-fired power plants generating electricity for various industrial and commercial sectors; Ministry of Electricity; General Electric Production Company and subsidiaries
Transformation (T)	Supplying electric energy to citizens and critical national infrastructure, ensuring continuous and reliable productivity
Worldview (W)	Delivering energy at minimal cost, distributed equitably across social classes, and minimizing environmental impacts
Owners (O)	Central and local governments involved in power generation development; Ministry of Electricity
Environmental Constraints (E)	Economic constraints (e.g., investment gaps, financial allocation shortages, liquidity issues); legal limitations (e.g., land acquisition); environmental constraints (e.g., excessive gas emissions, high temperatures, water scarcity); technical and infrastructural barriers (e.g., outdated and low-quality equipment, lack of expertise in design and development)

The development of the root definition was informed by a series of interviews conducted with managers and technical specialists from gas-fired power generation companies in southern Iraq, as well as through structured CATWOE analysis. The outcomes of this process were shared with the interviewees across multiple iterative rounds, and, following validation and refinement, the finalized root definition was established as follows:

"The purpose of Iraq's gas-fired electricity generation companies is to utilize the country's natural resources to produce electricity for Iraqi citizens (household consumption), industrial facilities (industrial consumption), and commercial establishments (commercial consumption) at the lowest possible cost and with equitable access across all social classes, while minimizing adverse environmental impacts. In pursuit of this mission, strategic policies for power plants are formulated by the central government—through the Ministry of Electricity—and local authorities. The presence of economic constraints (e.g., limited investment, inadequate financial allocations, liquidity shortages), legal barriers (e.g., land acquisition for expansion), environmental challenges (e.g., excessive emissions, elevated temperatures, water scarcity), and technical-infrastructural limitations (e.g., outdated and poor-quality equipment, lack of technical expertise in design and development) have compelled Iraq to rely on electricity imports from neighboring countries to meet the needs of key stakeholders. The primary objective of this system is to evaluate the efficiency of gas-fired power plants, conduct periodic monitoring and continuous improvement, and identify strengths and weaknesses in order to achieve established goals—namely, minimal environmental pollution, maximum

production efficiency, and optimal customer satisfaction."

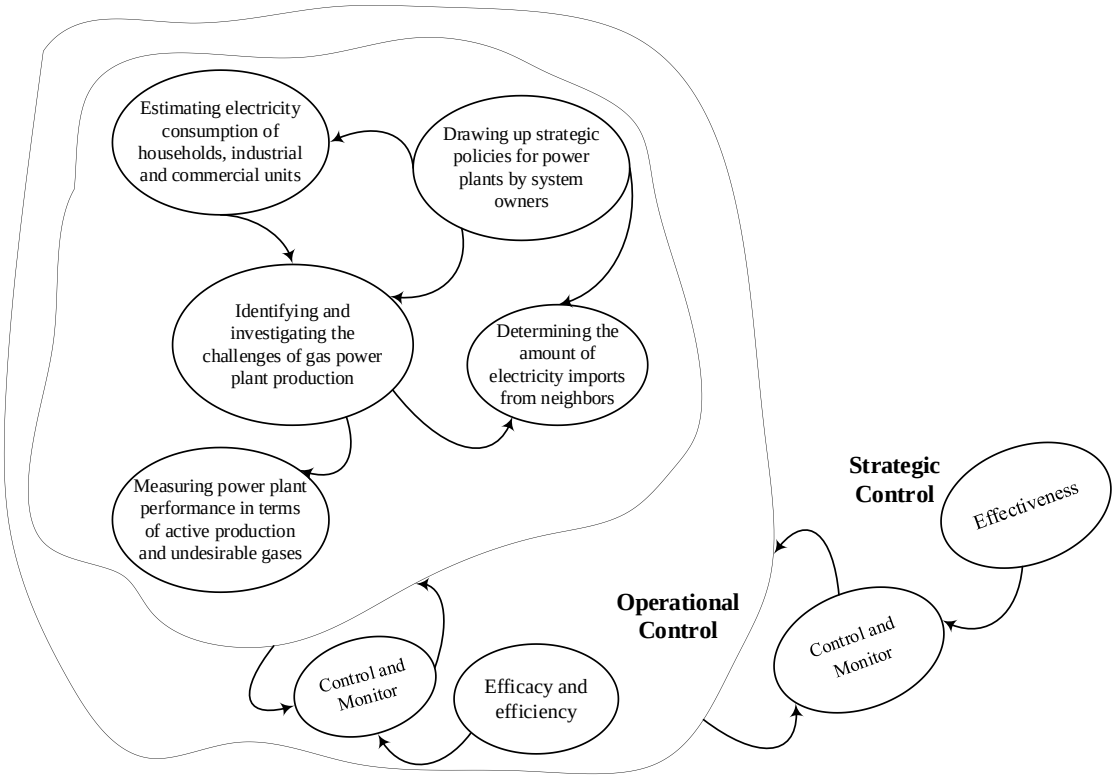
Step 4: Conceptual Model Development

In this stage of the Soft Systems Methodology (SSM) approach, the conceptual model of gas-fired electricity generation plants in Iraq is developed based on the previously formulated root definition and the 3E framework—comprising effectiveness, efficiency, and efficacy. Accordingly, an initial Level 1 conceptual model is constructed for the overall gas-fired electricity production system in Iraq, aimed at transforming inputs into desired outputs, such as electricity generation with minimal environmental impact and maximum customer satisfaction.

This model distinguishes between input resources and output outcomes while accounting for uncontrolled environmental variables such as ambient temperature. It further evaluates the functional dimensions of the system through the lens of the 3E framework. In this context, a PQR analysis was conducted to define performance criteria for each of the three core dimensions: (1) *Efficacy*—focused on the actual electricity output and pollutant levels; (2) *Efficiency*—concerned with the ratio of outputs to resource consumption such as fuel and electricity usage; and (3) *Effectiveness*—centered on the extent to which outputs align with higher-order objectives, including customer satisfaction and environmental protection. Figure 3 illustrates the conceptual model of Iraq's gas-fired electricity generation system, developed in accordance with the root definition.

Figure 3.

Conceptual Model of Gas-fired Electricity Generation Plants based on Root Definition



Given the complexity and multidimensional nature of the issue, the overarching conceptual model has been disaggregated into seven distinct subsystems. Each subsystem was developed at a lower level through expert interviews and qualitative content analysis, and possesses its own root definition based on Soft Systems Methodology (SSM):

- ***Economic Subsystem:*** Focuses on attracting foreign investment and managing liquidity within power plants to facilitate contractor payments, promote project development, and enhance workforce motivation.
- ***Environmental Subsystem:*** Aims to reduce pollution through a transition to renewable energies such as wind power, minimize industrial waste, and conserve water resources amid the critical conditions of the Tigris and Euphrates rivers.
- ***Supply Subsystem:*** Concentrates on improving fuel quality via filtration technologies and managing gas storage to regulate imports and address supply volatility across seasonal variations.
- ***Human Resources Subsystem:*** Targets the improvement of human resource management systems, provision of specialized staff training, and reduction of contractor dependency through technical skill development and morale strengthening.
- ***Technology and Infrastructure Subsystem:*** Envisions modernizing outdated networks, upgrading equipment, and deploying clean energy technologies, subject to adequate financial support.
- ***Social Subsystem:*** Seeks to promote public awareness and cultural transformation regarding responsible electricity consumption and prevention of misuse, emphasizing consumer-level behavioral interventions.
- ***Managerial Subsystem:*** Prioritizes organizational and administrative restructuring, capability-based planning, meritocratic governance, and the avoidance of non-specialist interference in strategic affairs.

Each of these subsystems interacts to form the broader system of gas-fired power plants in Iraq. In accordance with the SSM approach, they require continuous monitoring and performance evaluation using the 3E framework—effectiveness, efficiency, and efficacy (PQR). This multi-layered model not only enables more precise analysis through quantitative techniques such as Data Envelopment Analysis (DEA), but also provides a robust foundation for policy decision-making and structural reform within Iraq's electricity sector.

Soft Systems Methodology at the Subsystem Level

Given the specific focus on gas-fired power plants, the subsystems are defined through the identification and analysis of challenges related to power generation within these facilities. Accordingly, a separate root definition has been formulated for each subsystem, as presented in Table 3.

Table 3.

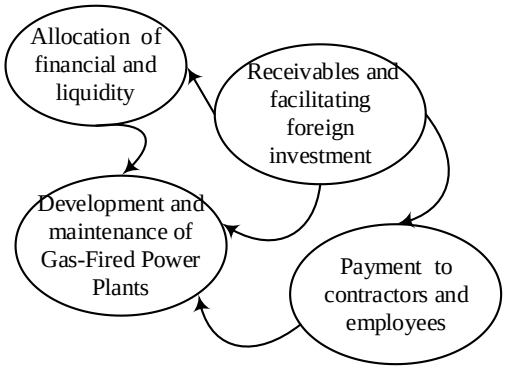
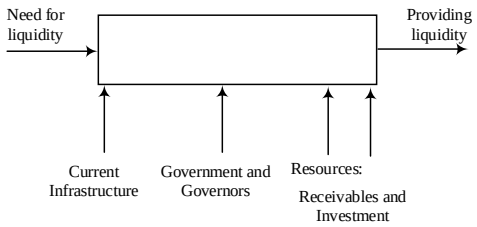
Root Definitions of Subsystems

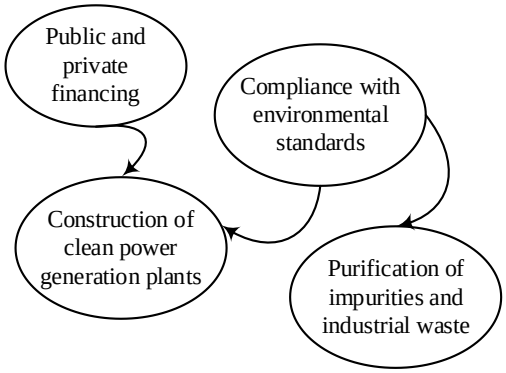
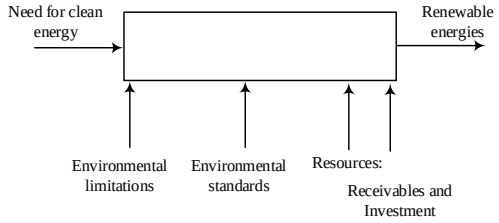
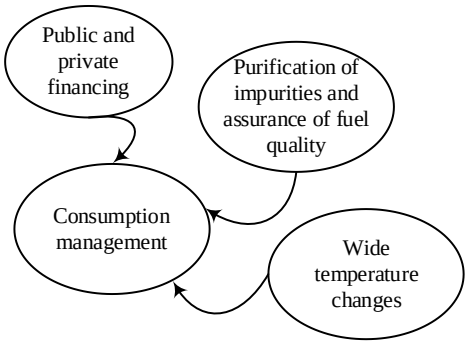
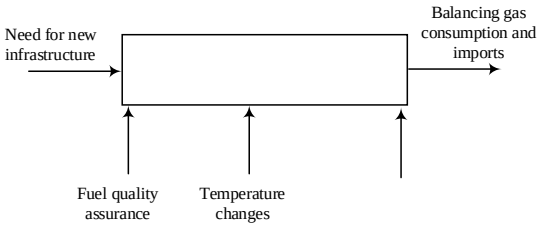
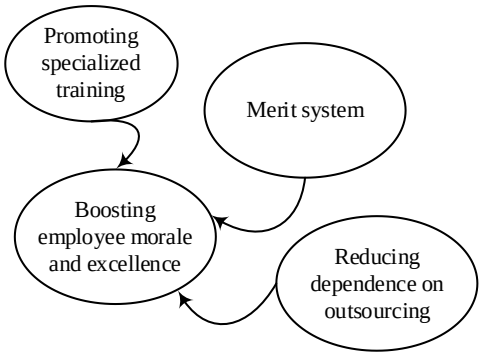
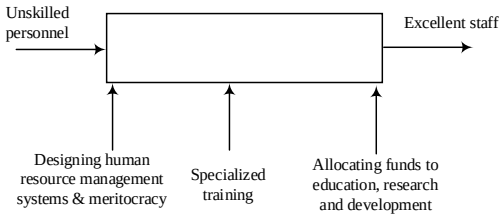
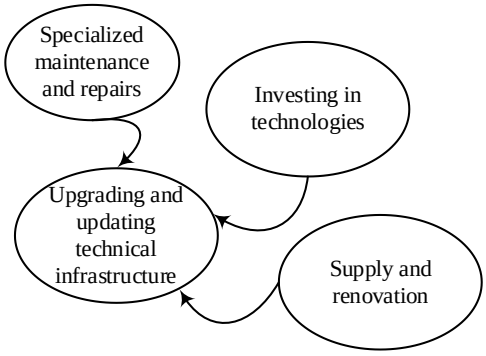
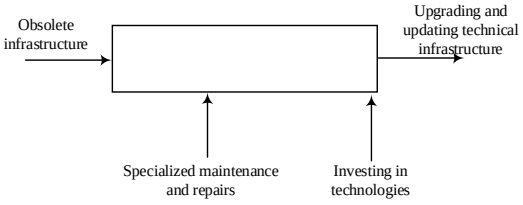
Subsystems	Root Definition
Economic	Enhancing liquidity in power plants through foreign investment and monitoring receivables, aimed at facilitating contractor payments, advancing project development, and improving the reward system to motivate personnel.
Environmental	Transitioning toward renewable energy sources such as wind to mitigate pollution beyond environmental standards, reduce industrial waste and emissions, and decrease water consumption in light of the critical condition of the Tigris and Euphrates rivers.
Supply	Utilizing purifiers and separators to improve fuel quality—given the prevalence of low-grade gas and impurities—and deploying storage tanks to balance gas consumption and manage import schedules throughout the year.
Human Resources	Advancing human resource management systems and specialized personnel training for handling complex and modern equipment, with the goal of reducing reliance on contract workers and fostering employee resilience and commitment.
Technology & Infrastructure	Securing necessary financial resources to strengthen operational systems, storage capacities, maintenance and repair protocols, modernize outdated networks, and adopt advanced renewable energy technologies.
Social	Promoting public awareness and cultural transformation to ensure responsible electricity usage and prevent misuse in power generation and distribution systems, in consideration of Iraq's changing demographic landscape.
Managerial	Improving managerial efficiency and effectiveness through administrative and organizational reform, with a focus on competency-based planning, meritocratic principles, and limiting non-specialist interference in management processes.

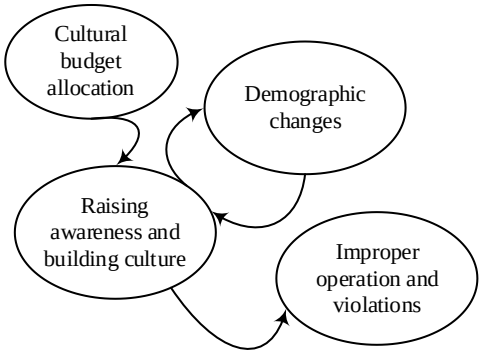
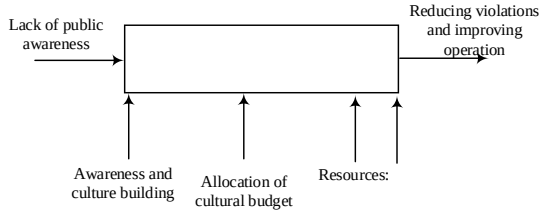
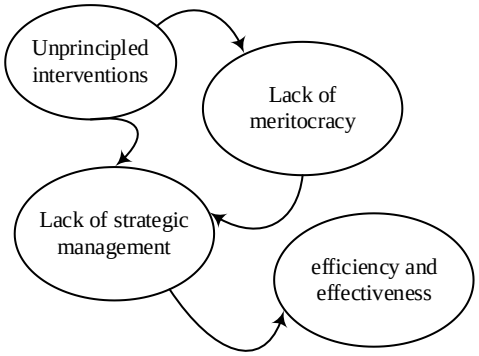
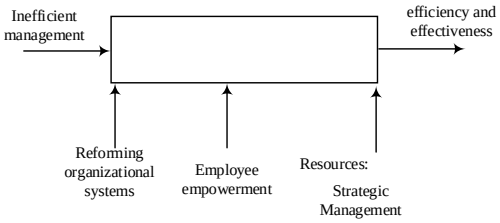
Conceptual and system models at the seven subsystem levels including economic, environmental, supply, human resource, technology & infrastructure, social, and managerial aspects depicted in Figure (4).

Figure 4.

Conceptual and System Models at the Subsystem Level

Subsystems	Conceptual Model	System Model
Economic		

Subsystems	Conceptual Model	System Model
Environmental		
Supply		
Human Resources		
Technology & Infrastructure		

Subsystems	Conceptual Model	System Model
Social		
Managerial		

DEA's Inputs and Outputs

In the evaluation of decision-making units, including gas-fired power plants, Data Envelopment Analysis (DEA) is recognized as one of the widely applied non-parametric methods. However, in many real-world studies, decision-makers face multiple objectives and priorities that are not necessarily achievable simultaneously. Under such circumstances, reliance solely on classical DEA may yield optimal—but unrealistic—results. Accordingly, in this study, Soft Systems Methodology (SSM) is employed to improve analytical precision and better align the DEA model with the actual multi-criteria conditions of the power plants, particularly in identifying relevant input and output variables.

In the technology and infrastructure dimension, factors such as reliance on obsolete equipment, lack of modern operational and monitoring systems, and scarcity of renewable technologies have contributed to decreased annual output, increased internal energy consumption, and heightened greenhouse gas emissions. Environmentally, challenges such as pollutant emissions, unsanitary waste disposal, and water shortages have had a direct impact on plant performance. Economically, deficiencies in investment, liquidity constraints, and inadequate financial resource allocation have undermined productivity. From a managerial and human resources standpoint, the absence of skilled personnel, insufficient training, and structural issues within the decision-making framework have led to serious inefficiencies. Socially, factors such as unplanned population growth, expansion of informal settlements lacking consumption infrastructure, and poor electricity-use culture have significantly affected the performance of the country's gas-fired power system. The development of the

conceptual and systemic model at the second level (i.e., the seven subsystems) resulted in the identification of key dimensions and indicators which are presented in Table 4.

Table 4.

Dimensions and Associated Indicators

Dimension	Indicators
Economic	Insufficient financial allocation and liquidity management Ineffective receivables collection Limited foreign investment
Environmental	Necessity to adopt renewable energy sources such as wind power Pollution exceeding standard thresholds Water resource scarcity
Supply	Inadequate and poor-quality gas fuel Lack of access to critical materials and spare parts
Human Resources	Absence of trained personnel Overreliance on contract-based labor Insufficient expertise in equipment design and development
Managerial	Absence of actionable planning aligned with existing capabilities Bureaucratic inefficiencies and non-specialist interference Poor appointment practices and disregard for meritocracy
Technology & Infrastructure	Deficiency in modern operational, maintenance, and monitoring systems Reliance on outdated technologies and deteriorated infrastructure Lack of renewable energy technologies such as wind power systems
Social	Expansion of informal settlements without metering systems Irregular population growth Low public awareness and culture regarding electricity usage

Based on these analyses, the final input and output variables were selected according to their relevance, measurability, and data availability. The findings presented in Table (4) demonstrate that the identified indicators can be redefined according to their measurable effects on both tangible inputs and quantifiable outputs. Notably, several indicators influence inputs and outputs concurrently. For instance, within the economic dimension, three key factors—insufficient financial allocation and liquidity management, ineffective receivables collection, and limited foreign investment—have substantially contributed to reduced electricity production in Iraq. These indicators simultaneously affect two critical variables: annual electricity production (output) and natural gas consumption (input) in gas-fired power plants.

Within the environmental dimension, several critical issues have significantly influenced both undesirable gas emissions and annual production outputs. The Necessity to adopt renewable energy sources such as wind power, pollution exceeding standard thresholds, and water resource scarcity, have collectively contributed to these operational challenges. Furthermore, the inadequate and poor-quality gas fuel, and Lack of access to critical materials and spare parts has adversely affected electricity generation capacity while simultaneously elevating natural gas consumption and associated emissions.

From an organizational management perspective, systemic human resource deficiencies have emerged as substantial

barriers to optimal plant performance. The absence of trained personnel, overreliance on contract-based labor, and insufficient expertise in equipment design and development have significantly compromised operational efficiency. These workforce challenges are compounded by strategic management shortcomings, including absence of actionable planning aligned with existing capabilities, bureaucratic inefficiencies and non-specialist interference, poor appointment practices and disregard for meritocracy principles. These interrelated factors, rooted in insufficient workforce development, training programs, and research and development investments, collectively impair electricity production capacity. Addressing these multidimensional challenges requires comprehensive reforms in both human resource management practices and broader organizational management strategies.

Within the technological and infrastructure dimension, deficiencies in modern operational, maintenance, and monitoring systems, coupled with continued reliance on outdated technologies and deteriorated infrastructure, have contributed to reduced annual electricity generation while simultaneously increasing both plant energy consumption (electricity depreciation) and emissions of environmentally harmful gases including carbon dioxide and methane. Furthermore, lack of renewable energy technologies such as wind power systems, has necessitated excessive consumption of natural gases, thereby exacerbating undesirable emissions. This technological gap has perpetuated Iraq's dependence on imported gas from neighboring nations to meet its energy demands.

From a social perspective, several factors have placed additional strain on electricity generation capacity. The expansion of informal settlements without metering systems, irregular population growth, and low public awareness and culture regarding electricity usage have collectively increased pressure on gas-fired power plants. These social challenges have further compounded the technical and infrastructural limitations, creating a multifaceted crisis in Iraq's energy sector.

Table (5) depicts dimensions, indicators, and scalable/quantifiable inputs and outputs for DEA model.

Table 5.

Scalable/quantifiable inputs and outputs for DEA

Dimension	Indicators	Inputs	Outputs
Economic	Insufficient financial allocation and liquidity management	-	Annual electricity production
	Ineffective receivables collection	-	Annual electricity production
	Limited foreign investment	Natural gas consumption	Annual electricity production
Environmental	Necessity to adopt renewable energy sources such as wind power	Natural gas consumption	Annual electricity production

Dimension	Indicators	Inputs	Outputs
Supply	Pollution exceeding standard thresholds	-	Unfavourable gases (CO2, CH4, N2O)
	Water resource scarcity	-	Annual electricity production
	Inadequate and poor-quality gas fuel	Natural gas consumption	Annual electricity production Unfavourable gases (CO2, CH4, N2O)
	Lack of access to critical materials and spare parts	-	Annual electricity production
Human Resources	Absence of trained personnel	Number of employees training programs, and research and development	Annual electricity production
	Overreliance on contract-based labor	Number of employees training programs, and research and development	-
	Insufficient expertise in equipment design and development	Number of employees training programs, and research and development	Annual electricity production Depreciation of electricity consumption
Managerial	Absence of actionable planning aligned with existing capabilities	Number of employees training programs, and research and development	Annual electricity production
	Bureaucratic inefficiencies and non-specialist interference	Number of employees	-
	Poor appointment practices and disregard for meritocracy	Number of employees	-
Technology & Infrastructure	Deficiency in modern operational, maintenance, and monitoring systems	-	Annual electricity production Unfavourable gases (CO2, CH4, N2O) Depreciation of electricity consumption
	Reliance on outdated technologies and deteriorated infrastructure	-	Annual electricity production Unfavourable gases (CO2, CH4, N2O)

Dimension	Indicators	Inputs	Outputs
			Depreciation of electricity consumption
	Lack of renewable energy technologies such as wind power systems	Natural gas consumption	Unfavourable gases (CO2, CH4, N2O)
	Expansion of informal settlements without metering systems	-	Annual electricity production
Social	Irregular population growth	-	Annual electricity production
	Low public awareness and culture regarding electricity usage	-	Annual electricity production

Discussion and Conclusion

The present study aims to develop an integrated framework for identifying input and output variables and applying Data Envelopment Analysis (DEA) to evaluate the efficiency of gas-fired power generation plants in southern Iraq. To this end, Soft Systems Methodology (SSM) was utilized to analyze the complex institutional, social, and managerial dimensions of the issue. The primary objective was to identify the root causes of inefficiency and propose system-based solutions to enhance power plant performance.

Upon initial examination, Soft Systems Methodology (SSM) and Data Envelopment Analysis (DEA) may appear fundamentally dissimilar, given that SSM is a conceptual approach grounded in subjective epistemology, whereas DEA constitutes a mathematical programming technique designed to assess the relative efficiency of decision-making units (DMUs) through input-output data analysis, reflecting a positivist paradigm (Mingers, 2003). Nevertheless, notable parallels exist between the two methodologies. Specifically, SSM can be effectively integrated with DEA for three compelling reasons, playing a critical role in defining the input and output indicators for DMUs. First, SSM offers a systematic and structured framework for analyzing an organization's key activities, which is essential for evaluating organizational efficiency and performance. In this context, the application of Root Definitions (RD) and Conceptual Models (CM) enhances problem structuring within the DEA methodology. Second, SSM incorporates diverse perspectives and worldviews in defining input and output variables. The methodology constructs models based on specific *Weltanschauungen* (worldviews) (Mingers, 2003), which may differ among stakeholders. These models represent notional or conceptual systems in which defined activities convert inputs into outputs delivered to a beneficiary. By systematically mapping stakeholders, their respective challenges, and the interactions between them, SSM facilitates a comprehensive identification of relevant inputs and outputs (Soltan Mohammadi et al. 2012). Finally, the definition of *transformation* in DEA varies depending on stakeholder perspectives. By employing SSM, consensus among key organizational stakeholders can be achieved when evaluating performance. Crucially, the conversion of

inputs into outputs constitutes the foundational mechanism of this integrated approach. This methodology significantly mitigates the influence of subjective decision-maker bias in selecting input and output variables for efficiency measurement. Grounded in systems thinking, SSM systematically identifies inputs and outputs by (1) mapping relevant stakeholders and their associated challenges, and (2) analyzing the interactions and relationships among them.

The findings reveal a significant discrepancy between input resources and actual output levels across most facilities. Moreover, results indicate that imbalanced utilization of human resources, inadequate specialized training, and heavy reliance on external contractors constitute key contributors to inefficiency within the human capital domain. These insights align with recent studies such as Wang et al. (2024) in Southeast Asian countries, where it is emphasized that human resource productivity is no less influential than technical factors in determining energy efficiency.

From a technical standpoint, several challenges were identified, including the failure to modernize equipment, the absence of performance control and monitoring systems, and the lack of advanced operational infrastructure. These findings align with the studies conducted by Li and Tao (2017) and Rahman et al. (2023), which underscore that purely technical analyses—when undertaken without consideration of operational frameworks and broader policy environments—do not yield effective solutions. In addition, the environmental dimension of power plant performance was examined, revealing that pollutant emissions in most units exceed global standards. Given the climatic conditions in southern Iraq, the lack of water recycling systems and weaknesses in gas storage and purification processes have exacerbated environmental challenges. These findings correspond with reports by the International Energy Agency (2024), which warn that fossil fuel-dependent countries must accelerate their transition toward clean energy sources to prevent compounding environmental and economic crises.

At the decision-making and institutional structure level, findings indicate the absence of integrated planning, excessive centralization in policymaking, and managerial instability. For example, most power plants lack the authority to attract investment or enter into long-term contracts for fuel and spare parts procurement, resulting in operational uncertainty. In addition, data reveal that poor consumption habits and the lack of public education on energy optimization have contributed to high levels of energy waste on the demand side. Comparative studies, such as the work by Fu et al. (2023) examining the electricity systems of Pakistan and Malaysia, have also highlighted that participatory policymaking and consumer-focused education exert a direct impact on reducing grid pressure and enhancing overall system productivity.

Based on the aforementioned findings, several practical recommendations can be proposed. First, the Iraq Government should prioritize targeted foreign investment for the modernization of power plant technologies and actively pursue public–private partnership models. Second, reforming the human resource structure—through redesigning recruitment, training, and promotion processes and gradually eliminating dependence on non-specialized contractors—is imperative. Third, the development of real-

time intelligent monitoring systems for fuel quality control, consumption management, and performance assessment at individual power plants could lead to continuous system optimization. Fourth, establishing provincial-level decision-making units with clearly defined financial and technical authority for power plants may help mitigate excessive centralization and reduce policy-making delays. Fifth, public education and awareness campaigns—implemented in collaboration with media outlets—should become a key component of the national energy strategy in order to sustainably manage electricity demand. Finally, a gradual transition to renewable energy sources in southern Iraq, particularly solar energy given the region's high climatic potential, must be addressed at the policy level.

The innovative contribution of the present study lies in its adoption of an integrated DEA–SSM approach, which, unlike existing regional literature, enables a multidimensional and in-depth analysis of power plant efficiency. In contrast to conventional studies that rely solely on technical assessments, this research simultaneously incorporates managerial, human, institutional, environmental, and technological factors—demonstrating that power plant efficiency is not exclusively a technical construct, but rather the outcome of interactive dynamics across various structural and functional layers.

Nevertheless, the study faced certain limitations. Chief among these was the restriction of the sample to power plants in southern Iraq and the lack of access to complete datasets for some facilities due to administrative and security constraints. Future researchers are encouraged to expand the geographical scope to include the entire country and to adopt dynamic modeling approaches that account for policy scenarios related to climate change and regional migration patterns. Additionally, exploring optimal energy portfolios—particularly solar and wind energy in southern Iraq—could offer a more strategic outlook for the nation's power sector.

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