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Designing an Interpretive Structural Model of Human Resource Productivity with a Focus on Occupational Health and Safety Management Systems in Iraq's Construction Industry

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A B S T R A C T

This study aims to design an interpretive structural model (ISM) of human resource productivity with a specific focus on occupational health and safety management systems in Iraq's construction industry. This research employs a mixed-methods design with both qualitative and quantitative components. Qualitatively, thematic analysis was applied to data gathered through expert interviews using a snowball sampling approach involving 10 university professors and industry managers. In the quantitative phase, the ISM technique was used to examine the structural relationships among dimensions and to stratify them hierarchically. The structural equation modeling (SEM) approach was applied using SmartPLS software with a sample of 384 civil engineers selected based on Cochran's formula. The reliability and validity of the measurement model were assessed through composite reliability, AVE, and confirmatory factor analysis, while model fit was evaluated using the Goodness of Fit (GoF) index. The qualitative analysis identified five key dimensions of human resource productivity: creating suitable employment, scientific training and development, effective communication, risk management, and rewards and incentives. ISM analysis stratified these dimensions into three levels, with "creating suitable employment" being the most dependent, and "scientific training and development" the most influential. SEM results confirmed all hypothesized relationships among constructs, with scientific training significantly impacting risk management, communication, and incentive systems. The model demonstrated strong convergent validity (AVE > 0.50) and composite reliability (> 0.70), and the overall model fit (GoF = 0.56) was deemed robust. The study confirms that investments in scientific training and development play a central role in enhancing human resource productivity through effective risk management, communication, and reward mechanisms in construction settings. Furthermore, implementing structured risk management systems and integrating immersive safety training technologies can lead to safer, more innovative, and productive work environments in Iraq's construction industry.

Keywords: *Human resource productivity; occupational safety and health; interpretive structural modeling (ISM); construction industry; risk management; Iraq.*

1. Introduction

The safety management system is based on components such as leadership and commitment, strategic policies and objectives, organizational resources and documentation, risk assessment and management, planning, implementation, and monitoring. The research and development of occupational health and safety (OHS) management systems in the workplace should be carried out through a logical and continuous improvement process. This can be achieved through the establishment of policies, assessments, audits, and improvement measures (Kurniawan et al., 2024; Lari, 2024).

Some scholars argue that organizations are governed by the industries they belong to and must take the necessary actions to achieve key performance indicators related to effectiveness and productivity. Accordingly, they organize, integrate, direct, and control resources to maximize profits. For this reason, it is stated that a sound strategy helps the organization in all its aspects by achieving a positive impact on society (Jiménez Ludeña, 2019).

The indicators that enhance workforce productivity within organizations reflect a nation's prosperity, as it depends on the capacity of its industries to maintain high and stable operational performance. It is essential for an organization to optimize its resource utilization to deliver its products and be managed by individuals whose objective is to maximize the use of these resources (Pan et al., 2022; Rajat, 2018).

The success of an organization is undoubtedly influenced by the work productivity of its employees. Human resources are those capable of planning, managing, and guiding the company's direction and strategic agenda. Therefore, every company consistently strives to enhance employee productivity in achieving predetermined organizational goals. Human resources must be managed professionally to achieve a balance between the needs of employees and the demands and capabilities of the organization. This balance is the key to the company's productive development (Kurniawan et al., 2024; Lari, 2024).

Hulu (2021) argues that work productivity is the ultimate outcome of an employee's efforts within a company or organization and can be reflected in the output produced both quantitatively and qualitatively (Hulu, 2021). The productivity of a company or organization is often expressed as the ratio of output to the human resources used. This highlights the vital role of human resources and productivity in determining success (Annisa et al., 2023).

Labor productivity within organizations is crucial because human resources are directly linked to effectiveness, efficiency, leadership, job satisfaction, training, and development (Naveed & Wang, 2022). Productivity is a critical factor as it reflects the proper use of available resources in achieving designated goals (Torrecilla-García et al., 2021). Effectiveness is defined as the ability to achieve objectives with minimal time, effort, and materials. Leadership enhances quality, productivity, and resource management by motivating employees toward productivity and effectiveness. A leader is responsible for decision-making. An employee's satisfaction with their work motivates them and positively influences productivity and organizational outcomes (Hulu, 2021; Jiménez Ludeña, 2019).

From the perspective of occupational health and safety management, performance indicators directly impact labor productivity, costs, employee motivation and satisfaction, and profitability, while also enhancing corporate image (Génesis et al., 2022). According to researchers, productivity represents the relationship between output (goods or services) and input (employees, materials, and money). It serves as a measure of production efficiency (Calligaris et al., 2016). The comparison between output and input is often constrained by the workforce, while output is measured in terms of physical condition, form, and value. Productivity is the comparison between the results produced by employees and all the resources a company uses to carry out production activities within a specific time frame (Padriansyah & Firmansyah, 2021).

Productivity may also be defined as the comparison between input and output based on work results achieved through employee activities within the organization, in relation to the assigned workload (Rios-Avila, 2020). According to scholars, productivity is the extent to which goods and services can be produced or increased through the optimal use of human resources. Thus, productivity is often interpreted as the ratio of output to input in a given unit. According to the National Productivity Council, productivity is a linear attitude that consistently envisions a better quality of life today than yesterday, and an even better one tomorrow than today.

Key aspects that must be revisited to ensure high productivity include the ability to manage the workforce, aspects related to labor efficiency, and aspects of the work environment. Company productivity includes both the productivity of machinery and equipment and the productivity of human labor. In this regard, labor or employees—based on the views of several experts—are seen as central. Researchers have concluded that employee productivity is an activity that benefits the success of a project or product in terms of the job responsibilities assigned to employees at a given time. Productivity is the ratio between the output that can be generated with overall enthusiasm and the satisfaction obtained through the dedication of employees (Creemers et al., 2023).

It is essential to develop ideas and innovations that maintain customer satisfaction and increase employee well-being. This is critical for companies aiming to enhance productivity—one way being the provision of occupational health and safety programs for all employees, especially field workers. These efforts aim to motivate and stimulate employees to work more productively. To implement these two dimensions effectively, companies must also enforce managerial disciplines as a strategy to improve productivity (Padriansyah & Firmansyah, 2021).

In the pursuit of increasing employee work productivity based on occupational health, several factors influence employee productivity within the company. These factors include both employee-related aspects and those linked to the company environment and general government policies (Gomez-Mejia et al., 2018). These factors are as follows:

1. **Conflict factors**: These refer to arguments, disputes, and conflicts between employees, or incompatibility arising from communication barriers, differences in goals and attitudes, and dependency on work activities. Such conditions can significantly affect employee performance.
2. **Occupational health and safety (OHS) factors**: These aim to create a healthy and safe work environment, influencing employee performance by reducing the risk of work-related injuries or illnesses caused by negligence, which may result in demotivation and low productivity.
3. **Motivational factors**: These are stimuli that drive employees to perform their duties. When motivation is high, employees experience joy and enthusiasm in their work, leading to advancement, growth, and increased productivity (Daspit et al., 2018).

Given that labor productivity is widely regarded as one of the most important indicators of organizational efficiency, it is surprising that only a limited number of studies have focused on human resource productivity based on occupational health and safety. Furthermore, the few research efforts conducted in this domain have often reported conflicting findings. This study seeks to address this gap by providing results that investigate human resource productivity based on occupational health within construction projects and by developing an effective model.

Accordingly, the research poses the following question:

What is the interpretive structural model of human resource productivity with a focus on occupational health and safety management systems in Iraq’s construction industry?

2. Methods and Materials

Given that the objective of this study is to design an interpretive structural model of human resource productivity with a focus on occupational health and safety management systems in Iraq's construction industry, the research method is categorized as exploratory-applied in terms of purpose; mixed (qualitative-quantitative) in terms of data type; cross-sectional in terms of data collection timeframe; inductive-deductive in philosophical orientation; and descriptive-survey in terms of data collection method and research nature.

The first part of the study employs a qualitative approach aimed at identifying, classifying, and extracting concepts based on the perspectives of experts and relevant professionals. The qualitative method used in this phase is thematic analysis.

The second part of the study adopts a quantitative approach, using input from the statistical population to examine the relationship between the study dimensions and the research topic, as well as to evaluate and test the identified components and dimensions. In this phase, thematic analysis was used to analyze interviews conducted with 10 experts.

In the second stage, which is the quantitative phase, interpretive structural modeling (ISM) was used to analyze the hierarchical levels of the dimensions. In the third step, the relationships among the dimensions were analyzed using structural equation modeling (SEM). Therefore, the data collection methods used in this study include both library and field research.

The qualitative research population consists of university professors and managers in Iraq's construction industry. Snowball sampling was used, and 10 experts were interviewed.

The statistical population for the structural equation modeling phase includes civil engineers in Iraq. Since the population is considered unlimited, the sample size was determined using Cochran's formula, resulting in 384 participants. Data collection was carried out using researcher-developed questionnaires.

The statistical population for the interpretive structural modeling phase includes 10 managers from Iraq's construction industry, selected randomly.

3. Findings and Results

In examining the average age of the interviewed experts, it was found that university professors and academic experts had the highest average age at 42.33 years, while managers in the construction industry had the lowest average age at 38.66 years.

Regarding work experience, it was found that university professors and academic experts had the highest level of professional experience with an average of 15.35 years, while construction industry managers had slightly less experience, averaging 13.50 years. Among the study participants, six held PhDs and four held master's degrees.

After analyzing the identified open codes extracted from the interviews, thematic definitions and labels were established in the final stage. The findings indicated that the key dimensions influencing human resource productivity—focusing on occupational health and safety management systems—are classified into five main themes: creating suitable employment, scientific training and development, establishing effective communication, risk management, and providing rewards and incentives. Each of these main themes includes several subcomponents, which are presented in the following:

Table 1

Extracted Secondary Codes Related to Human Resource Productivity Focusing on Occupational Health and Safety Management Systems

No.	Research Dimensions	Extracted Secondary Codes
1	Creating Suitable Employment	Assessing organizational vulnerability
		Continuous monitoring and evaluation of safety systems
		Evaluation of work-related stress levels
		Creating a suitable work environment
2	Scientific Training and Development	Continuous safety training for employees
		Mental health training
		Accident prevention training
		Ergonomics training
3	Establishing Effective Communication	Transparency in employee safety information
		Socialization of safety and health practices
		Developing open communication between managers and staff
		Training in safety communication skills
4	Risk Management	Developing risk coping strategies
		Comprehensive and periodic risk assessments
		Utilizing technology for risk identification
		Promoting employee participation in risk reduction
5	Providing Rewards and Incentives	Promotion of roles and responsibilities
		Developing incentive programs for safety improvement
		Providing financial and non-financial rewards to employees
		Encouraging the development of a positive organizational culture

The structural self-interaction matrix of the human resource productivity components—focused on occupational health and safety management systems in Iraq's construction industry—was developed using four types of conceptual relationships. This matrix was completed by relevant experts and professionals. The collected data were synthesized using the interpretive structural modeling (ISM) methodology, resulting in the finalized structural self-interaction matrix:

Table 2

Structural Self-Interaction Matrix

Component	Symbol	C1	C2	C3	C4	C5
Creating Suitable Employment	C1		-1	0	-1	0
Scientific Training & Dev.	C2	1		1	1	-1

Rewards and Incentives	C3	0	-1		2	1
Risk Management	C4	1	-1	2		0
Effective Communication	C5	0	1	-1	0	

The reachability matrix was obtained by converting the structural self-interaction matrix into a binary matrix of zeros and ones. At this stage, the level of dependence and influence of each component was identified. Based on the final reachability matrix, the levels of the components were determined. Components with high dependence appear at the top of the model, while those with high influence are placed at the base.

Table 3

Final Reachability Matrix

Component	Symbol	C1	C2	C3	C4	C5	Dependence
Creating Suitable Employment	C1		0	0	0	0	0
Scientific Training & Dev.	C2	1		1	1	1	4
Rewards and Incentives	C3	1	1		1	1	4
Risk Management	C4	1	0	1		1	3
Effective Communication	C5	1	1	1	1		4
Dependency		4	2	3	3	3	

To determine the relationships and hierarchical levels of the components of human resource productivity with a focus on occupational health and safety management systems in Iraq's construction industry, the output and input sets for each dimension/indicator must be extracted from the final reachability matrix. The results were categorized into three levels, as shown in Tables 5, 6, and 7.

Table 4

First Stage of Determining Component Relationships and Levels

Components	Output Set	Input Set	Intersection	Level
C1 – Creating Suitable Employment	0	1-2-3-4-5	0	1
C2 – Scientific Training & Development	1-3-4-5	3-5		
C3 – Rewards and Incentives	1-2-4-5	2-3-5		
C4 – Risk Management	1-3-5	2-3-5		
C5 – Effective Communication	1-2-3-4	2-3-4		

Table 5

Second Stage of Determining Component Relationships and Levels

Components	Output Set	Input Set	Intersection	Level
C2 – Scientific Training & Development	3-4-5	3-5		
C3 – Rewards and Incentives	2-4-5	2-4-5	2-4-5	2
C4 – Risk Management	3-5	2-3-5	3-5	2
C5 – Effective Communication	2-3-4	2-3-4		2

Table 6

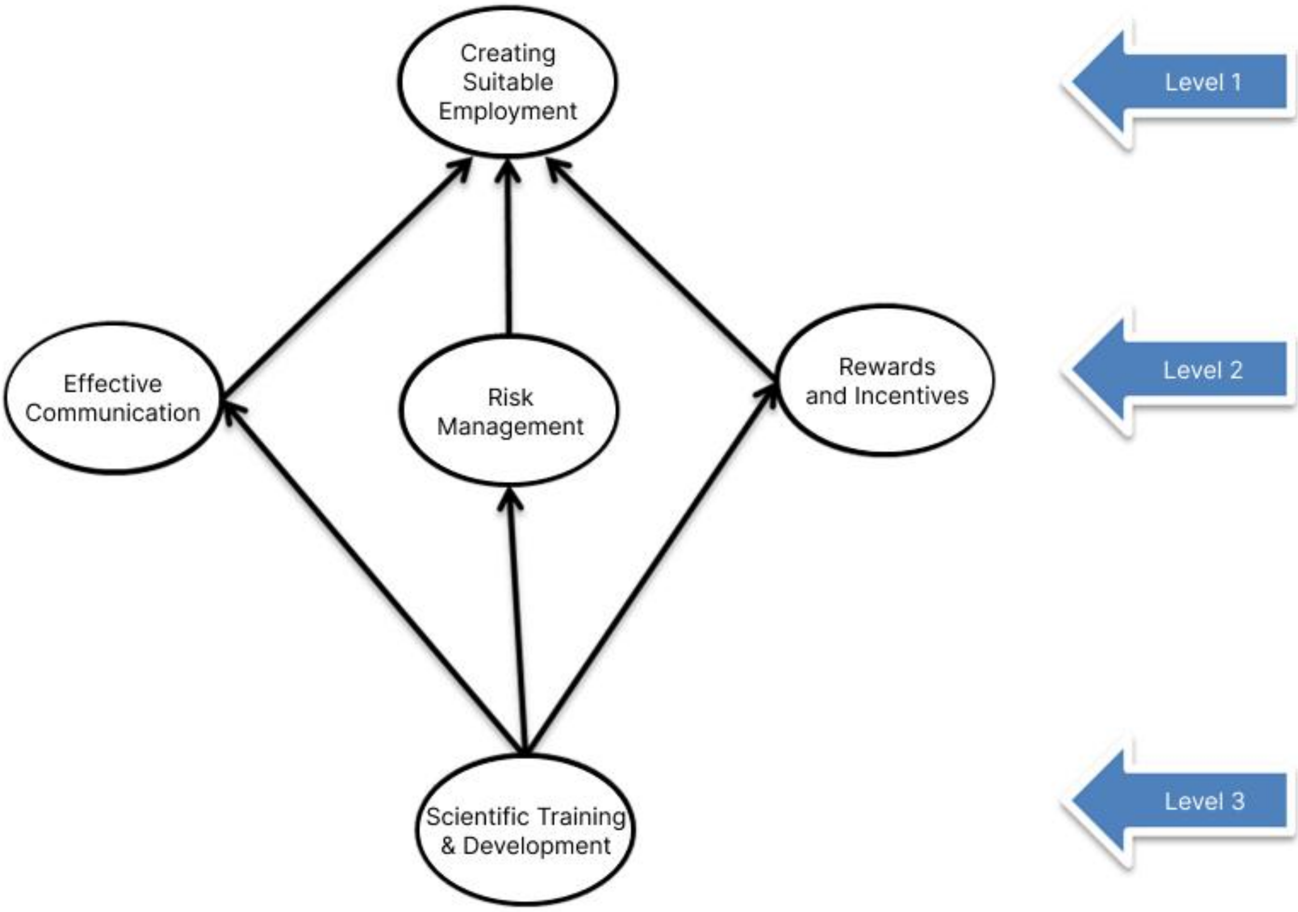
Third Stage of Determining Component Relationships and Levels

Components	Output Set	Input Set	Intersection	Level
C2 – Scientific Training & Development	0	0	0	3

The interaction network of the dimensions and indicators was generated using the output of interpretive structural modeling as the input for a network analysis software. The interaction network was drawn based on the relationships and hierarchical levels of the components influencing the design of the interpretive structural model for human resource productivity with a focus on occupational health and safety management systems in Iraq's construction industry:

Figure 1

Interactions of Research Components



The hierarchical categorization of the components is presented the following. The most influenced component is positioned at Level 1, while the most influential component appears at Level 3.

Table 7

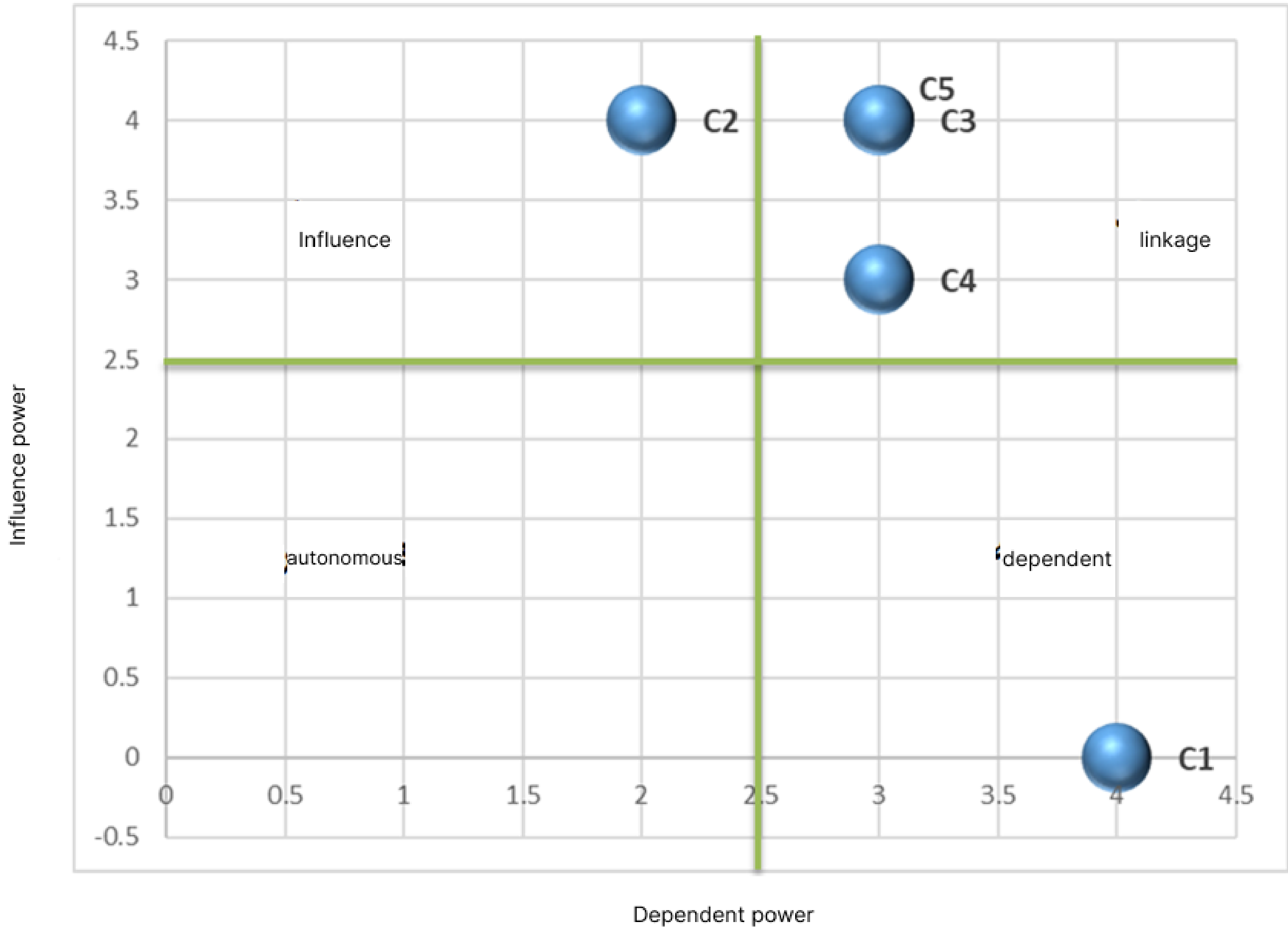
Summary of Component Hierarchies

Level	Components
1	Creating Suitable Employment
2	Rewards and Incentives, Risk Management
3	Scientific Training and Development

MICMAC analysis is a method for graphically representing variables based on their driving power and dependence within interpretive structural modeling. Based on the variables' influence and dependence, a coordinate system can be defined and divided into four equal quadrants. MICMAC analysis evaluates each variable's power of influence (driving power) and degree of dependence (dependence), allowing for detailed analysis of the scope and dynamics of each factor. Based on the influence and dependence values, Figure 4 was developed.

Figure 2

Influence-Dependence Interactions



According to the figure, the components fall into the linkage zone.

1. The first category includes "Autonomous Variables." These components have low dependence and low driving power. Components in this category operate largely independently from the system and have minimal interaction with other components. In this study, no component was classified as autonomous.
2. The second category includes "Driving Variables," which have high driving power but low dependence. Modifying these components can influence all other variables. The component Scientific Training and Development was located in this quadrant.
3. The third category includes "Linkage Variables," which possess both high driving power and high dependence. These variables are inherently unstable, meaning that any action taken concerning these components directly impacts others and can, in turn, receive feedback. The components in this category are: Rewards and Incentives, Risk Management, and Effective Communication.
4. The fourth category includes "Dependent Variables," which have low driving power but high dependence. In this study, the component Creating Suitable Employment was placed in the dependent zone.

To examine the relationships between the study's dimensions, structural equation modeling (SEM) was employed. The calculations are provided in the following section.

In the analysis of the average age of the experts surveyed, it was found that managers had the highest average age at 46.62 years, while civil engineers had the lowest average age at 40.11 years.

Regarding average work experience, the results indicated that managers had the highest level of professional experience at 15.34 years, while university professors and academic experts had less experience, averaging 13.29 years.

Among the participants in the present study, 40% of the managers held bachelor's degrees, 40% held master's degrees, and 20% held doctoral degrees. In contrast, 45% of the engineers had bachelor's degrees, 40% had master's degrees, and 15% held doctoral degrees.

To evaluate the research items, confirmatory factor analysis was used.

Table 8

Factor Loadings, Standard Errors, T Statistics, and P Values for Measurement Items

Item	Construct	Factor Loading	Standard Error (SE)	t Statistic	p Value	Status
Q1	Creating Suitable Employment	.781	.018	44.513	< .001	Confirmed
Q2	Creating Suitable Employment	.794	.018	43.519	< .001	Confirmed
Q3	Creating Suitable Employment	.809	.016	50.590	< .001	Confirmed
Q4	Creating Suitable Employment	.786	.018	44.232	< .001	Confirmed
Q5	Scientific Training & Dev.	.798	.017	46.054	< .001	Confirmed
Q6	Scientific Training & Dev.	.768	.019	39.885	< .001	Confirmed
Q7	Scientific Training & Dev.	.806	.017	47.919	< .001	Confirmed
Q8	Scientific Training & Dev.	.827	.015	55.983	< .001	Confirmed
Q9	Effective Communication	.807	.018	45.805	< .001	Confirmed
Q10	Effective Communication	.801	.017	48.023	< .001	Confirmed
Q11	Effective Communication	.807	.017	47.824	< .001	Confirmed
Q12	Effective Communication	.807	.015	52.651	< .001	Confirmed
Q13	Risk Management	.817	.017	49.200	< .001	Confirmed
Q14	Risk Management	.796	.017	47.388	< .001	Confirmed
Q15	Risk Management	.817	.016	52.402	< .001	Confirmed
Q16	Risk Management	.789	.019	42.613	< .001	Confirmed
Q17	Rewards and Incentives	.841	.015	57.817	< .001	Confirmed
Q18	Rewards and Incentives	.799	.017	46.953	< .001	Confirmed
Q19	Rewards and Incentives	.794	.017	47.400	< .001	Confirmed
Q20	Rewards and Incentives	.781	.019	42.095	< .001	Confirmed

According to the results, all indicators are statistically significant at a significance level of less than 0.05 (P-VALUE < 0.05). Additionally, all factor loadings exceed 0.4, indicating that the second-order factor loadings are confirmed.

After evaluating the measurement models, the structural model, and the overall model, following the algorithm of data analysis in the PLS method, the researcher is permitted to examine and test the relationships among the variables.

In this section, standardized path coefficients related to the hypotheses and corresponding t-values are examined. To confirm or reject a hypothesis, the t-value must be greater than 1.96 or less than -1.96. Values between these thresholds indicate no significant difference from zero in the regression weights at a 95% confidence level.

Figure 3

Model with Standardized Path Coefficients.

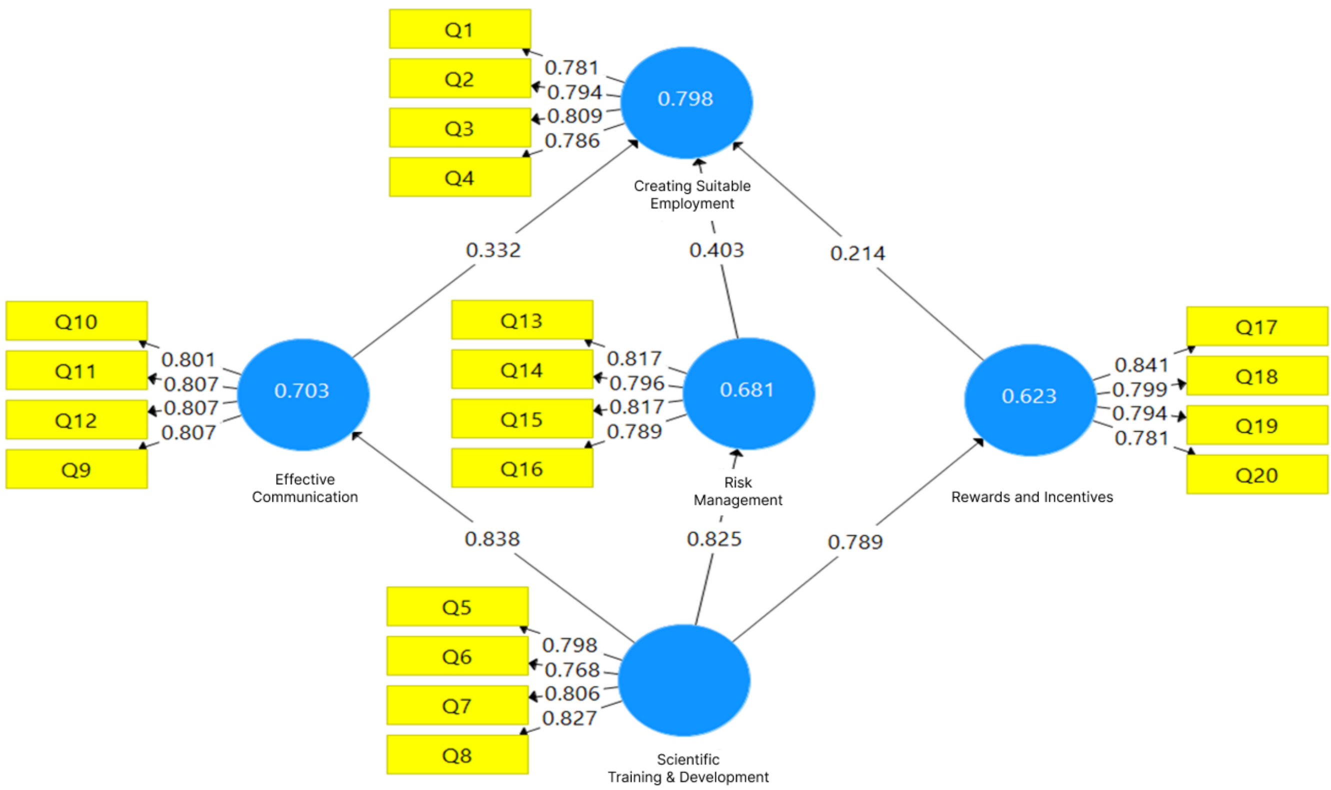


Figure 4

Model with the T-values

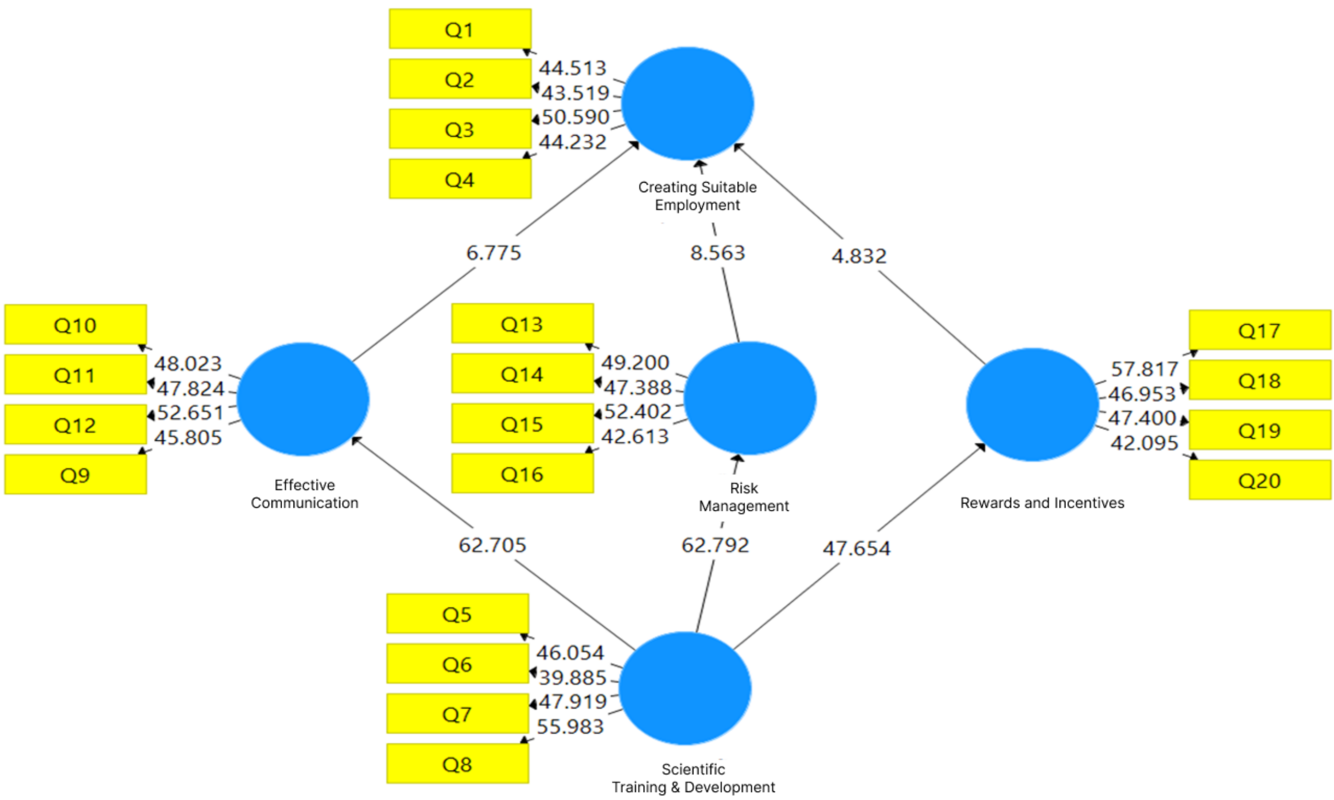


Table 9

Reliability Metrics

Construct	Cronbach's Alpha	rho_A	Composite Reliability
Scientific Training & Dev.	0.812	0.814	0.877
Rewards and Incentives	0.818	0.819	0.880
Effective Communication	0.820	0.820	0.881
Creating Suitable Employment	0.802	0.803	0.871
Risk Management	0.818	0.819	0.880

According to the results, all values for Cronbach's alpha and composite reliability exceed 0.70, indicating the reliability of the research data.

Fornell and Larcker (1981) introduced the AVE (Average Variance Extracted) criterion for assessing convergent validity, stating that the critical threshold is 0.50. An AVE value above 0.50 indicates acceptable convergent validity.

For second-order constructs, the AVE must be calculated manually using the following formula. Table 13 presents the AVE values for the research variables, all of which are above the threshold of 0.50.

Fornell and Larcker (1981) introduced the Average Variance Extracted (AVE) criterion for assessing convergent validity and stated that the critical threshold for AVE is 0.50. An AVE value greater than 0.50 indicates acceptable convergent validity. For second-order constructs, AVE must be calculated manually using the following formula.

Table 10

Convergent Validity

Construct	Composite Reliability	Average Variance Extracted (AVE)
Scientific Training & Development	0.877	0.640
Rewards and Incentives	0.880	0.647
Effective Communication	0.881	0.649
Creating Suitable Employment	0.871	0.628
Risk Management	0.880	0.647

It is observed that the AVE values are consistently greater than 0.50, and all composite reliability values exceed 0.70 and are also greater than the AVE values. Therefore, convergent validity is confirmed.

To evaluate the overall model fit—which includes both the measurement model and the structural model—the Goodness of Fit (GoF) index was used. GoF is calculated using the following formula:

(1) $GOF = \sqrt{(average\ communalities \times average\ R^2)}$

Table 14 shows the average communalities and average R^2 values. Based on these, the GoF value was calculated as 0.56, which indicates a strong model fit.

Table 11

Average Communalities and R^2 Values

Component	R^2	Communality	Average Communality	Average R^2
Scientific Training & Development	—	0.425	0.478	0.701
Rewards and Incentives	0.623	0.457		
Effective Communication	0.703	0.567		
Creating Suitable Employment	0.798	0.529		
Risk Management	0.681	0.413		

Table 12

Results of Relationships Between Research Dimensions and Components

Pathway	Path Coefficient	t Value	p Value	Status
Scientific Training & Development → Rewards and Incentives	0.789	47.654	< .001	Confirmed
Scientific Training & Development → Effective Communication	0.838	62.705	< .001	Confirmed

Scientific Training & Development → Risk Management	0.825	62.792	< .001	Confirmed
Rewards and Incentives → Creating Suitable Employment	0.214	4.832	< .001	Confirmed
Effective Communication → Creating Suitable Employment	0.332	6.775	< .001	Confirmed
Risk Management → Creating Suitable Employment	0.403	8.563	< .001	Confirmed

Based on the results:

- The relationship between scientific training and development and rewards and incentives is significant ($t = 47.654$, $t > 1.96$), with a path coefficient of 0.78, indicating a meaningful effect.
- The relationship between scientific training and development and effective communication is significant ($t = 62.705$, $t > 1.96$), with a path coefficient of 0.83.
- The relationship between scientific training and development and risk management is significant ($t = 62.792$, $t > 1.96$), with a path coefficient of 0.83.
- The relationship between rewards and incentives and creating suitable employment is significant ($t = 4.832$, $t > 1.96$), with a path coefficient of 0.21.
- The relationship between effective communication and creating suitable employment is significant ($t = 6.775$, $t > 1.96$), with a path coefficient of 0.33.
- The relationship between risk management and creating suitable employment is significant ($t = 8.563$, $t > 1.96$), with a path coefficient of 0.40.

Since all t-values are greater than 1.96, all relationships are statistically significant and confirmed.

4. Discussion and Conclusion

In explaining the results obtained, it can be stated that rewards and incentives increase the motivation of engineers and construction professionals to learn, conduct research, and develop their skills. When they know that their efforts are recognized and rewarded, they pursue knowledge and skill development with greater enthusiasm, leading to increased productivity in the industry. Another consequence is the attraction and retention of skilled professionals. Construction companies that value scientific training and development and provide rewards for it are more likely to attract talented specialists and retain them within their organizations. This is especially important in a competitive labor market.

Improving work quality and fostering innovation are other important effects. Engineers who receive continuous training and skill upgrades are able to provide higher-quality and more innovative services. Incentives and rewards reinforce this process and result in the production of higher-quality and more innovative projects. Moreover, continuous training and the updating of knowledge in new fields and advanced technologies in the construction industry help reduce human error and increase safety in projects. When engineers are familiar with the latest standards and methods, the likelihood of errors and accidents decreases.

Scientific training and development in the construction industry is closely related to risk management, as updated knowledge and skills significantly improve the ability to identify, assess, and mitigate potential risks. This relationship can be observed in several ways:

Risk Identification: Specialized training and continuous knowledge updates familiarize engineers with the latest standards, methods, and technologies. This familiarity helps them identify potential risks that may arise in construction projects. For example, familiarity with new soil analysis methods can help identify risks related to ground settlement.

Risk Assessment: Engineers who have received advanced training in areas such as project management, value engineering, modeling, and simulation can assess risks more accurately and better predict their likelihood and severity.

Risk Mitigation: Scientific training introduces engineers to various risk reduction techniques, including detailed planning, the use of modern technologies, quality management, project control, and implementation of best operational practices. For instance, training in advanced concrete casting methods can reduce the risk of cracks and defects in concrete structures.

Risk Response Planning: Training in risk management enables engineers to develop detailed plans for responding to identified risks. These plans include preventive measures, corrective actions, and emergency responses in the event of incidents.

Improved Decision-Making: Greater knowledge and awareness of risks help engineers make more informed and effective decisions at different stages of the project. This leads to reduced costs, time savings, and enhanced project quality.

Enhanced Safety: Training in occupational health and safety reduces safety hazards and prevents accidents. This contributes to employee well-being and overall improvement in project quality.

Ultimately, scientific training and development foster a culture of safety and risk management in the construction industry, leading to safer, more efficient, and higher-quality projects. Neglecting training and scientific development increases the likelihood of errors and accidents and significantly raises the costs associated with risks. Effective risk management in construction projects leads to project completion on time, within budget, and at a higher quality. Successful projects, in turn, lead to increased demand for skilled labor and the creation of more job opportunities in this sector. Conversely, failed projects due to poor risk management may result in fewer job opportunities and even job losses for some individuals.

Creating a safer work environment is another aspect of this relationship. Risk management in construction projects means establishing a safer workplace for engineers and workers. Reducing job-related injuries and accidents improves job satisfaction and makes the work environment more appealing for skilled talent. Enhancing project quality is another outcome of the relationship between risk management and suitable job creation. Risk management contributes to improving the quality of construction projects. Higher-quality projects, in turn, increase the demand for highly skilled specialists and result in the creation of more specialized and better-paying jobs.

Risk management can also lead to innovation and the adoption of advanced technologies in construction projects. These innovations, in turn, create new and specialized jobs in technology-related fields. For instance, the use of Building Information Modeling (BIM) methods has generated new job opportunities in various software and modeling domains.

Another important factor is investor attraction. Projects with well-managed risks are more appealing to investors. Increased investment, in turn, leads to a higher volume of projects and more employment opportunities.

This conclusion aligns with the prior findings (Chi et al., 2023; Creemers et al., 2023; Kurniawan et al., 2024)

Accordingly, the following recommendations are proposed for Iraq's construction industry:

1. **Establish Specialized Risk Management Courses in Higher Education**: Enhance the knowledge and skills of civil engineering students and professionals by developing comprehensive training courses covering key risk management topics such as risk identification, assessment, mitigation techniques, and monitoring. Invite industry experts to share their experiences and engage in knowledge exchange with students. Incorporate group projects and risk management simulations requiring students to identify and plan for construction project risks. Assess students based on their practical abilities in risk identification, response, and decision-making.
2. **Implement Risk Management Systems in Real Projects**: Strengthen risk management skills through the establishment and implementation of risk management systems in actual projects under senior supervision. Identify complex and large-scale construction projects suitable for risk system implementation. Form multidisciplinary teams of young and experienced engineers to develop and execute a comprehensive risk management framework. Train team members in advanced risk management tools and their application. Execute risk management stages including identification, analysis, response planning, and implementation while documenting all phases. Continuously monitor and evaluate the system's performance and establish feedback mechanisms for continuous improvement.
3. **Implement Data-Driven Risk Management Systems in Construction Projects**: It is recommended to identify and manage risks in construction projects effectively to enhance workplace safety and promote sustainable employment opportunities. Suggested actions include: conducting initial meetings with project teams to identify potential risks across all phases (planning, execution, and delivery); using analytical techniques such as SWOT, PESTEL, and previous project analyses to detect similar risks; creating a risk management matrix including identification, evaluation, and classification of risks by likelihood and impact; categorizing risks as high, medium, or low to prioritize actions; developing specific plans for each risk category including avoidance, mitigation, transfer, or acceptance; and applying data analytics and artificial intelligence to predict hazards and identify project vulnerabilities.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

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