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Research article

Evaluating the impact of internet communication quality in human resource management on the productivity of construction projects

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ABSTRACT

This research endeavors to examine the intricate relationship between human resource management and communication management in Iraqi construction projects, exploring their impact on project productivity. Beyond its primary objectives, the study aims to identify key challenges and limitations in implementing effective communication and human resource management practices in the Iraqi construction sector. Understanding these challenges provides valuable insights for practitioners and policymakers, informing strategies to overcome obstacles and enhance project productivity. The research methodology involves an initial survey using a main questionnaire, focusing on three key areas: internet communication in human resource management, the influence of internet quality on construction project management, and factors affecting work productivity. The sample size, determined using Morgan's Table, requires a minimum of 248 participants. The questionnaire is distributed to engineers, managers, and technicians, with the number of respondents meeting the required sample size. Data analysis utilizes the Statistical Package for Social Sciences (SPSS), conducting Exploratory Factor Analysis (EFA) for each variable to identify underlying factors. A first-order confirmatory factor analysis is performed using the Analysis of Moment Structures (AMOS) program, creating a structural model incorporating three variables and their associated factors. Out of the initial 64 factors, 21 are included in the final model, refined based on modification indices (M.I) output to improve fit. Results indicate a significant positive effect (0.92) of internet communication quality on labor productivity, while the impact of labor resource management is relatively negligible (−0.07). The size effect of variables on human resource management is 0.05, suggesting a small but non-zero effect. Overall, the findings underscore the importance of internet communication quality in enhancing labor productivity in construction projects and emphasize the need for effective human resource management practices in the industry. This study contributes valuable insights for project managers and practitioners in construction sector.

1. 1- Introduction

Construction projects play a crucial role in achieving economic efficiency, creating job opportunities, and developing the reality of any country. This is especially important for countries like Iraq, which has faced successive wars and unstable political and security

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conditions. The current era is witnessing rapid developments and changes due to the information, communication, and technology revolution. With the increasing waves of development and technological progress, there is a need to increase the communication process. The development of communication devices has resulted in unprecedented benefits due to the ease of communication flow in the world, reducing borders and barriers. However, managers of construction projects face challenges and problems in keeping pace with these rapid changes. As a result, the concepts of production and operation management were developed in projects, and other vital concepts were introduced, including the idea of quality and control of production remotely by devices dedicated to production management [1,2].

The main problems faced by project managers on the majority of Iraqi projects were identified through comprehensive discussions with managers from various service departments, including water and sanitation, municipalities, and electricity departments in governorates such as Wasit, Karbala, Babylon, and Najaf. The discussions covered a large number of issues that hinder the implementation of construction projects, with a special focus on the most prominent ones, such as poor communication between the manager and workers, lack of communication, and many disputes that delay the completion of the project on time, failure to update management plans (communication - risks - time), not updating the appropriate changes during the project, time management, additional costs, and some psychological stress. Communication management factors were chosen because in the time of COVID-19, the most important factor in remote project management is communication with project staff. After all, most projects are run using internet services and social media software. For this reason, communication factors and methods of communication between officials and workers must be sought to improve productivity in construction projects [3].

Communication is the most important factor in a construction project for the job to run smoothly apart from human resources. Without good communication between the parties involved in the project, it can cause delays and disputes that negatively affect the project's performance. Effective communication can help reduce disputes in construction projects [4]. Communication management practices, clarity in the scope of the construction project, and organizational culture are essential to enhance project success [5]. To improve communication in construction projects, appropriate communication management practices should be identified [3].

The study in Ref. [6] suggests that information and communication technology (ICT) can provide powerful strategic and tactical tools for organizations, which, if properly applied and used, could bring significant advantages in promoting and strengthening their competitiveness. The study in Ref. [7] focuses on current levels of ICT practice and the benefits derived from ICT (the explication of the acronym along with all other acronyms can be discerned within Table 18). ICT refers to technologies that provide access to information through telecommunications, including the internet, computers, and other communication mediums. In conclusion, construction projects were selected for their importance in the development of society, their role in economic life, and the number of problems in these types of projects. Paying attention to these projects through paying attention to workers and defining the relationship between human resources management and communication management on the productivity of construction projects in Iraq and the need to find understandable formulas and the extent of their impact in addition to providing appropriate solutions to it.

2. 2- Background

The impact of internet communication quality in human resource management on the productivity of construction projects constitutes a compelling subject for scholarly inquiry. While there are no search results that directly address this topic, there are several related studies that can provide insights, one study in a scholarly investigation conducted by Xie and Yang [8] discusses the risk management mode of construction project management in the multimedia environment of the Internet of Things. The study shows that communication management and quality control management are crucial in ensuring that construction projects are completed on time and with high quality. The study also emphasizes the importance of effective risk management in construction projects, which can be achieved through the combination of theory and practice. Another study by Bukhari et al. [9], reviews the human resource management (HRM) practices in construction organizations. The study identifies the HRM practices of the construction industry acknowledged by researchers from 2007 to 2019. The study shows that HRM practices are crucial to the performance of construction organizations. The study also highlights the importance of leadership styles, employee-related dimensions, competitive success factors, and organizational norms and practices in HRM.

A third study by Kokkaew [10] investigates the current practices of human resource management (HRM) in construction industry. The study compares and contrasts the current HRM practices between the construction industry and other industries, as well as between companies in the construction sector and those in other sectors. The study shows that HRM practices are mostly concerned with gaining value through increased skills, and productivity. Regarding productivity, studies discussing the basic factors for increasing production have been published previously [11–16]. To improve productivity in construction project delivery, key factors such as project planning, productivity measurement, avoidance of construction site congestion, motivation of workforce, and good communication should be considered, Additionally, effective work-based training components can help quantify the variations in the performance and productivity levels of labor in building construction projects [12]. Identifying the factors that impact the relationship between the productivity of a work and the outcome of construction projects is crucial for improving labor productivity. Factors affecting the productivity of construction labor include work performance, human resource practices, and labor performance factors. Furthermore, the supervisors have experience and can provide technical information to the workers, which positively affects the productivity of workers [17].

To ensure the quality of work, workers should be evaluated after the completion of each project and assigned a stimulus for their work, as well they must be qualified before being hired on larger projects. Also, workers must participate in seminars and conferences, which must be a prerequisite for the recruitment, promotion, selection, and placement of workers for the institution or company [18]. As for effective communication in construction projects, previous studies examined the following, effective communication, mutual trust, and commitment of all stakeholders are key factors that contribute to a successful strategic partnering process [19]. A study on the importance of communication management in improving the performance of construction project managers in developing countries found that communication is crucial for effective project management and that the failure to build communication with all project stakeholders can result in project failure [3]. the determination of career planning and decision making found that communication skills are essential for managing human resources [20], A study on the influence of communication on project success found that communication is the key to effective project management and that the adoption of ICT can yield remarkable results on effective

Fig. 1. Main themes, key aspects, studies, factors influencing productivity, and challenges in the context of internet communication quality in HRM and their impact on construction project productivity.

teamwork [21], An article on culture and human resource management found that communication is an essential aspect of human resource management [22].

Effective project communication management is crucial for the success of engineering projects. Despite the existence of various principles, methods, and ICT tools, many projects still fail or require fixing due to improper management and communication problems [23]. To improve project communication management, it is essential to identify realistic practices and their main factors described in the literature and use them in research to select the most appropriate models for construction projects and teams [23,24]. Some key factors that contribute to effective project communication management include, Information technology, Utilizing ICT tools to facilitate communication and information exchange among project stakeholders, communication skills and competence: Ensuring that project team members possess the necessary communication skills to effectively convey information and collaborate with others, communication management plan: Developing a comprehensive plan that outlines communication processes, channels, and responsibilities for all project stakeholders, teamwork: Encouraging collaboration and positive relationships among project team members, clear channels within the organization's structure: Establishing well-defined communication channels to facilitate information flow and reduce misunderstandings [25]. In addition to these factors, proper personal communication with project team members, developing positive relationships, and following the principles of transparent and positive communication rules are also essential for ensuring proper and effective project communication [23,26].

However, studies have shown that architects and engineers often have little information and knowledge in project communication management, and standards and methodologies are not always [27]. To address this issue, it is crucial to introduce communication management as an evolving knowledge area in the field of project management and provide training and resources to help professionals develop the necessary competencies [27]. In summary, while there are no direct studies on the impact of internet communication quality in human resource management on the productivity of construction projects, related studies suggest that communication management and quality control management are crucial in ensuring that construction projects are completed on time and with high quality. Effective HRM practices are also crucial to the performance of construction organizations. To improve productivity in construction project delivery, key factors such as project planning, productivity measurement, avoidance of construction site congestion, motivation of workforce, and good communication should be considered. Effective work-based training components can also help quantify the variations in the performance and productivity levels of labor in construction projects.

The provided synopsis has been condensed and presented in Fig. 1. This chart delineates the principal themes, key facets, antecedent research endeavors, determinants affecting productivity, and challenges within the realm of online communication quality in human resources management. It further explores the consequential effects on the productivity of construction projects.

3. Methodology

The methodology has been segmented into three distinct sections for enhanced clarity, as delineated below.

3.1. Study design

The research encompasses the participation of a cohort of ten consultants originating from Wasit Governorate. Within this group, three consultants are affiliated with Wasit University, while the remaining seven consultants hold the pivotal role of project managers, overseeing projects directly linked to the governorate.

Similarly, the study involves the inclusion of ten consultants associated with the Babylon Municipality. Among this cadre, two consultants hold the distinguished positions of project managers, actively engaged in the direct supervision of projects. The remaining eight consultants possess specialized expertise in the domain of construction project management.

Furthermore, the research encompasses the involvement of five consultants who serve as representatives of the Karbala Municipality. Each of these consultants occupies the esteemed position of construction project manager, responsible for overseeing projects within the Karbala region.

Additionally, the study features the participation of seven consultants hailing from Najaf Governorate, all of whom assume pivotal roles as managers overseeing civil projects situated within the Najaf province.

3.2. Sampling techniques

Within Wasit Governorate, the engineering workforce comprises a total of 1300 individuals, spanning both the public and private sectors. Among this cohort, 65 engineers are actively engaged in government-sponsored construction projects. Employing Morgan's table [28] as a foundational framework, the sample size selected from Wasit encompasses 56 individuals.

Morgan's table comprises pre-determined values, commencing with the parameter N denoting the population size and the parameter S denoting the sample size. As an illustration, consider the actual effective size in construction projects denoted by N, which is established at 65 individuals. Referring to Source [28], it was observed that the value assigned to S is 56 individuals)see Table 17).

Turning to Babylon Governorate, the aggregate count of engineers within the public and private spheres stands at 2200 professionals. Among this contingent, 85 engineers specialize in construction projects within the government sector. In alignment with the guidelines provided by Morgan's table [28], the sample size for Babylon was determined to encompass 70 individuals.

In the context of Karbala Governorate, the total number of engineers, comprising both the public and private domains, attains a count of 1400 individuals. Among them, 70 engineers assume pivotal roles in government-affiliated construction projects, encompassing both managerial and technical capacities. Following the principles delineated in Morgan's table [28], the sample size for

Karbala was established at 59 individuals.

Similarly, within Najaf Governorate, the cumulative engineer count reaches 1500 individuals. Among this assembly, 75 engineers are actively engaged in government-funded construction projects, holding diverse managerial and technical positions. In accordance with the methodology presented by Morgan's table [28], the sample size derived from Najaf encompasses 63 individuals.

In aggregate, the cumulative sample size encompasses 248 individuals, a cohort that also comprises 32 consultants, who are integral components of the study.

3.3. Research methodology

The proposed study aims to investigate the nuances of Internet communication quality and its impact on productivity and human resource management in the context of construction projects. The objective is to develop a comprehensive structural model that is both valid and feasible, as depicted in Fig. 7. This study utilizes two prominent software applications, namely AMOS and SPSS, to aid project managers in enhancing the successful execution and productivity of their respective projects through meticulous exploration. The survey questionnaire, a pivotal instrument in this research, was carefully crafted to encapsulate insights from experienced engineers in construction project management. The participating engineers were organized into distinct groups, with one subset specializing in the management of construction projects and the other in project management as a whole. These questionnaires were meticulously designed to encompass factors crucial to escalating work productivity within construction projects, the multifaceted impacts of Internet communication on human resource management, and the contributory factors that underscore the quality of Internet communication in the specific context of construction projects within Iraq. The sample size for this research was selected in accordance with Morgan's established criteria [28], culminating in a cohort of 248 respondents. This cohort comprised both construction project managers and technicians affiliated with construction projects within the public sector. The research framework encompasses a total of 28 variables linked to construction project management, 26 variables pertaining to the quality of Internet connectivity, and 10 variables related to increasing productivity of construction projects. These variables have been meticulously documented and can be found in the appendix (refer to Tables A1, A2, and A3), the details of which were collected using a blend of online and self-administered data collection methodologies. Responses from the participants were recorded on a 5-point Likert scale [29], ranging from 1 (indicating strong disagreement) to 5 (indicating strong agreement). After the data collection phase, the reliability (AVE - Average Variance Extracted) and the convergent and discriminant validity (CR - Composite Reliability) of the questionnaire were assessed through the utilization of AMOS, supported by the application of Kaiser-Meyer-Olkin measure, facilitated by SPSS. The outcomes of these analyses were consistent and adhered to acceptable thresholds, with values surpassing 0.5 for AVE and exceeding 0.7 for KMO [30]. Post data collection and statistical description of the gathered data (refer to Tables 1–5), an exploratory factor analysis was conducted, as detailed in Table 6. Subsequently, within the AMOS software, a confirmatory factor analysis was conducted at the primary level (refer to Tables 7–9). During this phase, each variable was scrutinized alongside its pertinent factors. Factors with a loading value below 0.4 in both software applications were systematically excluded. Upon completion of these analytical steps, the AMOS software was utilized to draft a standardized model encompassing the three identified factors. This model, composed of 51 variables distilled from the exploratory and confirmatory factor analyses, is elucidated in Fig. 5. Through the 'model fit' procedure within the 'output' section of the AMOS software [31], the values of the standard model were extracted (refer to Table 10). However, the results of this initial model were deemed inadequate. To rectify this inadequacy and attain a satisfactory standard model, the prescribed steps outlined in the section titled "Improvement of the Measurement Model" were meticulously followed. After iterating through the aforementioned steps, a standardized model emerged, depicted in Fig. 6. This model encapsulates 21 factors exerting influence on productivity, as detailed in Table 11. The results concerning this model were found to be acceptable and were endorsed, culminating in the establishment of a robust standard model applicable within construction projects. Following the meticulous identification of pertinent parameters within the standard model, the model transitioned into a Structural Equation Model (SEM) through the reconfiguration of arrows, as delineated in the segment titled "Model Conversion (CFA) of the Measurement Model to Structural Model (SEM)" (refer to Fig. 7 and Table 12). This evolved model is designed to elucidate the intricate interplay between the quality of Internet connectivity and its repercussions on human resource management, subsequently influencing the elevation of productivity within construction projects. This meticulously constructed template holds substantial utility, serving as a valuable resource for construction project managers operating within the Iraqi projects.

4. Results

The outcomes were partitioned into three crucial sections with the aim of deriving a structural model, and each section will be expounded and elucidated as follows.

Table 1
Frequency distribution of sample people by gender.

Gender	Statistical indicators		
	Frequency	frequency percentage	Cumulative frequency percentage
Male	194	78.2	78.2
Female	54	21.8	100
Total	248	100	

Table 2
Frequency distribution according to education.

Education	Statistical indicators		
	Frequency	Frequency percentage	Cumulative frequency percentage
Ph.D. degree	34	13.7	13.7
Master's degree	21	8.5	22.2
Bachelor's degree	122	49.2	71.4
Post-graduate diploma	61	24.6	96
Diploma	10	4	100
Total	248	100	

Table 3
Distribution of frequency by age.

Age	Statistical indicators		
	Frequency	Frequency percentage	Cumulative frequency percentage
Between 37 and 45 years	96	38.7	38.7
Above 46 years	60	24.2	62.9
Between 25 and 36 years	55	22.2	85.1
Less than 25 years	37	14.9	100
Total	248	100	

Table 4
Frequency distribution of sample people according to work experience.

Work experience	Statistical indicators		
	Frequency	Frequency percentage	Cumulative frequency percentage
More than 26 years and above	87	35.1	35.1
Between 16 and 20 years	51	20.6	55.7
Between 21 and 25 years	45	18.1	73.8
Between 11 and 15 years	34	13.7	78.5
Between 6 and 10 years	29	11.7	99.2
Less than 5 years	2	0.8	100
Total	248	100	

Table 5
Frequency distribution of sample people according to administrative position.

Administrative position	Statistical indicators		
	Frequency	Frequency percentage	Cumulative frequency percentage
Project manager	79	31.9	31.9
Assistant Project Manager	103	41.5	73.4
Administrative manager of the project	38	15.3	88.7
Project accountant	28	11.3	100.0
Total	248	100.0	

4.1. Descriptive statistics

To provide a comprehensive understanding of the individuals included in this study, the following section aims to clarify the frequency distribution of the sample population based on various demographic variables. Additionally, to enable a nuanced comparative evaluation of the distribution patterns within the subject cohort, the numerical representation of individuals classified by distinct demographic attributes is supplemented by presenting these figures as relative percentages, like (gender, education, age, work experience, administrative position)

4.1.1. Gender

The segmentation of the sample cohort with respect to gender delineated those 194 respondents (constituting 78.2%) identified as male, while 54 respondents (equivalent to 21.8%) identified as female. The amalgamation of frequency and percentage values presented in the distribution analysis conspicuously accentuates the preponderance of the male cohort over their female counterparts. These findings are succinctly encapsulated in Table (1), offering a comprehensive representation of the discerned gender distribution outcomes [32,33].

Table 6
Rotated component matrix values (EFA) from SPSS software.

Variables	Code	Max. Rotated factors matrix	Code	Max. Rotated factors matrix	Code	Max. Rotated factors matrix	Code	Max. Rotated factors matrix
Human Resources Management	H1	0.394	H8	0.810	H15	0.787	H22	0.798
	H2	0.501	H9	0.811	H16	0.829	H23	0.746
	H3	0.449	H10	0.829	H17	0.713	H24	0.812
	H4	0.814	H11	0.817	H18	0.751	H25	0.369
	H5	0.767	H12	0.838	H19	0.727	H26	0.374
	H6	0.712	H13	0.787	H20	0.806	H27	0.367
	H7	0.779	H14	0.812	H21	0.726	H28	0.358
Quality of Internet Communication	Q1	0.073	Q8	0.859	Q15	0.822	Q22	0.968
	Q2	0.040	Q9	0.888	Q16	0.914	Q23	0.972
	Q3	0.013	Q10	0.441	Q17	0.942	Q24	0.442
	Q4	0.303	Q11	0.914	Q18	0.956	Q25	0.470
	Q5	0.902	Q12	0.883	Q19	0.883	Q26	0.967
	Q6	0.185	Q13	0.968	Q20	0.951		
	Q7	0.903	Q14	0.882	Q21	0.948		
Productivity	P1	0.361	P4	0.887	P7	0.955	P10	0.785
	P2	0.920	P5	0.911	P8	0.362		
	P3	0.918	P6	0.853	P9	0.310		

Table 7
Regression weight values (CFA) & (EFA) & (AVE) and checking the composite reliability for productivity by SPSS & AMOS software.

Variables	Code	CFA	EFA	P-Value	AVE	C.R Composite Reliability	Cronbach's Alpha	KMO
Productivity	P1	0.398	0.361	–	0.539	0.911	0.961	0.857
	P2	0.966	0.920	***				
	P3	0.964	0.918	***				
	P4	0.940	0.887	***				
	P5	0.964	0.911	***				
	P6	0.526	0.853	***				
	P7	0.529	0.955	***				
	P8	0.333	0.362	–				
	P9	0.385	0.310	–				
	P10	0.863	0.785	***				

4.1.2. Education

With respect to educational attainments, the outcomes emanating from the division of the sample populace according to their educational backgrounds are as follows: A contingent of ten individuals (constituting 0.4 percent) within the sample exhibited attainment of a diploma. Meanwhile, a substantial cohort of 122 individuals (comprising 49.2 percent) held a bachelor's degree. In addition, 61 individuals (representing 24.6 percent) had a post-graduate diploma. A further group, encompassing 21 individuals (equivalent to 8.5 percent), possessed a master's degree, while a distinct subset of 34 individuals (accounting for 13.7 percent) had achieved the pinnacle of academic qualification with a Ph.D. The comprehensive portrayal of frequency and its corresponding percentage values, as encapsulated by the distribution of the sample population across various educational levels, underscores a noteworthy observation: individuals possessing a bachelor's degree dominate the distribution, attesting to their marked preeminence within the sampled cohort. These findings are cogently presented in Table (2), which serves as an illustrative platform encapsulating the outcomes of this distribution [34,35].

4.1.3. Age

In the context of age demographics, the findings stemming from the segmentation of the sample population based on age categories are as follows: A total of 37 individuals (constituting 14.9 percent) were situated in the age bracket below 25 years, whereas 55 individuals (representing 22.2 percent) fell within the age range spanning from 25 to 36 years. Additionally, a cohort of 96 individuals (accounting for 38.7 percent) exhibited ages between 37 and 45 years. Notably, an identical count of 96 individuals (also equating to 38.7 percent) shared the age group between 37 and 45 years. Furthermore, a contingent of 60 individuals (reflecting 24.2 percent) were categorized as being above 46 years of age. A detailed summary of these discernments is aptly presented in Table (3), which serves as an illustrative repository for these distributional outcomes. It merits emphasis that the amalgamation of frequency and its respective percentage values underscore a discernible pattern: the category of individuals aged between 37 and 45 years garners a preeminent representation within the sampled populace. This empirical observation accentuates the marked significance of this age group within the context of the sample composition [36].

4.1.4. Work experience

Regarding individuals within the professional, the outcomes arising from the classification of sampled participants according to their work experience are as follows: Two individuals (accounting for 0.8 percent) exhibited less than five years of experience, while 29

Table 8
Regression weight values (CFA) & (EFA) & (AVE) and checking the composite reliability for human resource management by SPSS & AMOS software.

Variables	Code	CFA	EFA	P-Value	AVE	C.R Composite Reliability	Cronbach's Alpha	KMO
Human Resources Management	H1	0.385	0.394	–	0.502	0.973	0.962	0.956
	H2	0.495	0.501	***				
	H3	0.439	0.449	***				
	H4	0.814	0.814	***				
	H5	0.768	0.767	***				
	H6	0.714	0.712	***				
	H7	0.778	0.779	***				
	H8	0.812	0.810	***				
	H9	0.812	0.811	***				
	H10	0.831	0.829	***				
	H11	0.820	0.817	***				
	H12	0.838	0.838	***				
	H13	0.791	0.787	***				
	H14	0.811	0.812	***				
	H15	0.786	0.787	***				
	H16	0.831	0.829	***				
	H17	0.717	0.713	***				
	H18	0.753	0.751	***				
	H19	0.732	0.727	***				
	H20	0.808	0.806	***				
	H21	0.727	0.726	***				
	H22	0.800	0.798	***				
	H23	0.748	0.746	***				
	H24	0.813	0.812	***				
	H25	0.338	0.369	–				
	H26	0.339	0.374	–				
	H27	0.331	0.367	–				
	H28	0.358	0.358	–				

Table 9
Regression weight values (CFA) & (EFA) & (AVE) and checking the composite reliability for Internet communication quality by SPSS & AMOS software.

Variables	Code	CFA	EFA	P-Value	AVE	C.R Composite Reliability	Cronbach's Alpha	KMO
Internet Connection Quality	Q1	0.073	0.073	–	0.516	0.957	0.962	0.833
	Q2	0.034	0.040	–				
	Q3	0.033	0.013	–				
	Q4	0.387	0.303	–				
	Q5	0.939	0.902	***				
	Q6	0.381	0.185	–				
	Q7	0.926	0.903	***				
	Q8	0.888	0.859	***				
	Q9	0.910	0.888	***				
	Q10	0.513	0.441	***				
	Q11	0.425	0.913	***				
	Q12	0.924	0.883	***				
	Q13	0.407	0.968	***				
	Q14	0.921	0.882	***				
	Q15	0.881	0.822	***				
	Q16	0.403	0.914	***				
	Q17	0.403	0.942	***				
	Q18	0.977	0.956	***				
	Q19	0.412	0.883	***				
	Q20	0.961	0.951	***				
	Q21	0.959	0.948	***				
	Q22	0.981	0.968	***				
	Q23	0.980	0.972	***				
	Q24	0.505	0.442	***				
	Q25	0.521	0.470	***				
	Q26	0.406	0.967	***				

individuals (constituting 11.7 percent) reported a tenure ranging between 6 and 10 years. Furthermore, 34 individuals (equivalent to 13.1 percent) amassed work experience spanning 11–15 years, whereas 51 individuals (comprising 20.6 percent) had an experiential range of 16–20 years. Moreover, 45 individuals (reflecting 18.1 percent) had accrued between 21 and 25 years of professional engagement. Notably, 87 individuals (up 35.1 percent) had amassed substantial work experience surpassing 26 years. This latter

Table 10
Fit indices of the measurement model after removing the factors less than 0.4

Result Fitness	Fit index	Acceptable value	The value of the model	The result is suitable
Absolute fit indices	GFI	0.9<	0.377	Unsuitable
	RMR	close to zero	0.138	Suitable
Comparative fit indices	NFI	0.9<	0.541	Unsuitable
	CFI	0.9<	0.566	Unsuitable
	RFI	0.9<	0.520	Unsuitable
	IFI	0.9<	0.567	UnSuitable
Thrifty fit indicators	PRATIO	0.5<	0.958	Suitable
	PCFI	0.5<	0.542	Suitable
	RMSEA	It is good if it is smaller than 0.05	0.188	Unsuitable
		And if it is between (0.05 and 0.08), the model is average		
	CMIN/DF	Less than 3	9.707	Unsuitable

Table 11
Model fit indices measure the dimension of model improvement.

Result Fitness	Fit index	Acceptable value	The value of the model	The result is suitable
Absolute fit indices	GFI	0.9<	0.907	Suitable
	RMR	close to zero	0.045	Suitable
Comparative fit indices	NFI	0.9<	0.945	Suitable
	CFI	0.9<	0.981	Suitable
	RFI	0.9<	0.937	Suitable
	IFI	0.9<	0.981	Suitable
Thrifty fit indicators	PRATIO	0.5<	0.862	Suitable
	PCFI	0.5<	0.846	Suitable
	RMSEA	It is good if it is smaller than 0.05	0.045	Suitable
		And if it is between (0.05 and 0.08), the model is average		
	CMIN/DF	Less than 3	1.498	Suitable

Table 12
Structural model fit indices.

Result Fitness	Fit index	Acceptable value	The value of the model	The result is suitable
Absolute fit indices	GFI	0.9<	0.907	Suitable
	RMR	close to zero	0.045	Suitable
Comparative fit indices	NFI	0.9<	0.945	Suitable
	CFI	0.9<	0.981	Suitable
	RFI	0.9<	0.937	Suitable
	IFI	0.9<	0.981	Suitable
Thrifty fit indicators	PRATIO	0.5<	0.862	Suitable
	PCFI	0.5<	0.846	Suitable
	RMSEA	It is good if it is smaller than 0.05	0.045	Suitable
		And if it is between (0.05 and 0.08), the model is average		
	CMIN/DF	Less than 3	1.498	Suitable

category denotes a significantly matured level of professionalism. These findings are concisely displayed in Table 4, offering a comprehensive representation of the distribution outcomes. Of particular interest, the cumulative presentation of frequency and its corresponding percentage values underpin the salient observation that the subgroup characterized by individuals exceeding 26 years of work experience commands a predominant presence within the sampled population. This empirical observation underscores the pivotal import of this category in the context of the sampled cohort [37].

4.1.5. Administrative position

From an organizational standpoint, the outcomes derived from the categorization of sampled individuals by their administrative roles revealed a delineation as follows: 79 individuals (constituting 31.9 percent) assumed positions as Project Managers, 103 individuals (comprising 41.5 percent) undertook roles as assistant Project Managers, 38 individuals (reflecting 15.3 percent) held positions as Administrative Managers of the project, and an additional 38 individuals (representing 11.3 percent) occupied roles as Project Accountants. The tabulated presentation of these findings, as expounded in Table 5, provides a comprehensive overview of this distribution outcome. Notably, the aggregation of frequency and corresponding percentage values pertaining to the sampled cohort's distribution underscores the prominence of the category denoted as Assistant Project Managers. This particular subgroup manifests the most substantial presence within the sampled population, as elucidated by the empirical data [38].

4.2. Exploratory factor analysis (EFA)

SPSS software was used to perform factor analysis. Specifically, the maximum likelihood technique alongside the Varimax procedure is employed to ascertain factor loading coefficients for each variable. These coefficients are presented in Table 6 as a rotated factor matrix. To refine the structural model, variables exhibiting factor loading coefficients below the threshold of 40% are removed from the model [39,40], as indicated in Table 6.

4.3. Confirmatory factor analysis (CFA)

Leveraging the AMOS software, the graphical representation of each variable alongside its corresponding factors is effectuated, akin to the exemplified illustrations in Figures (2)–(4). The execution of this software yields both standard and non-standard factor loading coefficients. Subsequent to this analytical procedure, discernment emerges regarding the weight attributed to each factor within the model. Notably, factors exhibiting weights less than 40% are subjected to exclusion, aligning with the process exemplified in Tables (7)–(9). This meticulous culling mechanism serves to refine the model by ensuring that only the most substantively influential factors are retained, thus augmenting the precision and comprehensibility of the model.

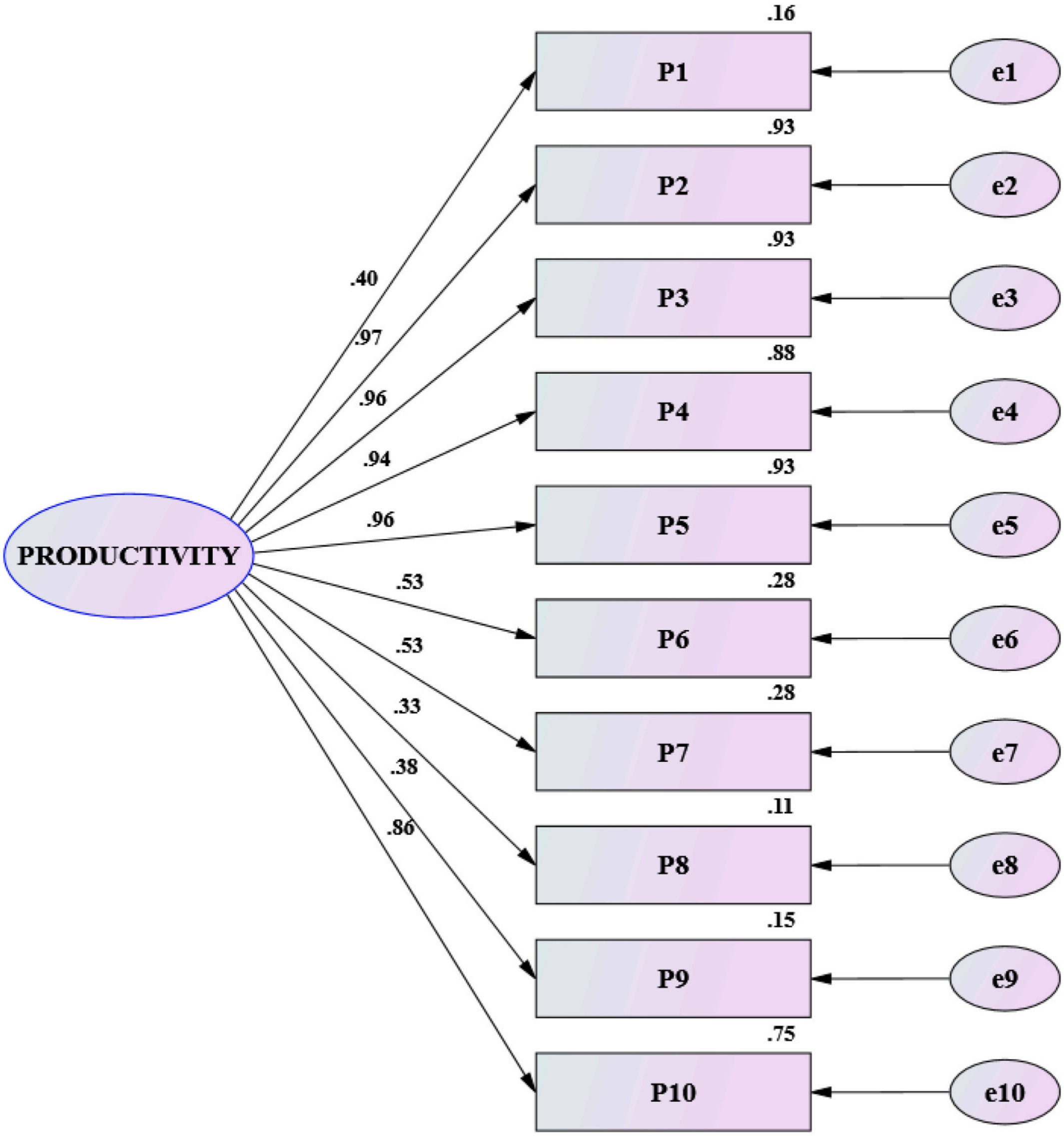

Fig. 2. First-order confirmatory factor analysis of productivity in standard estimation mode.

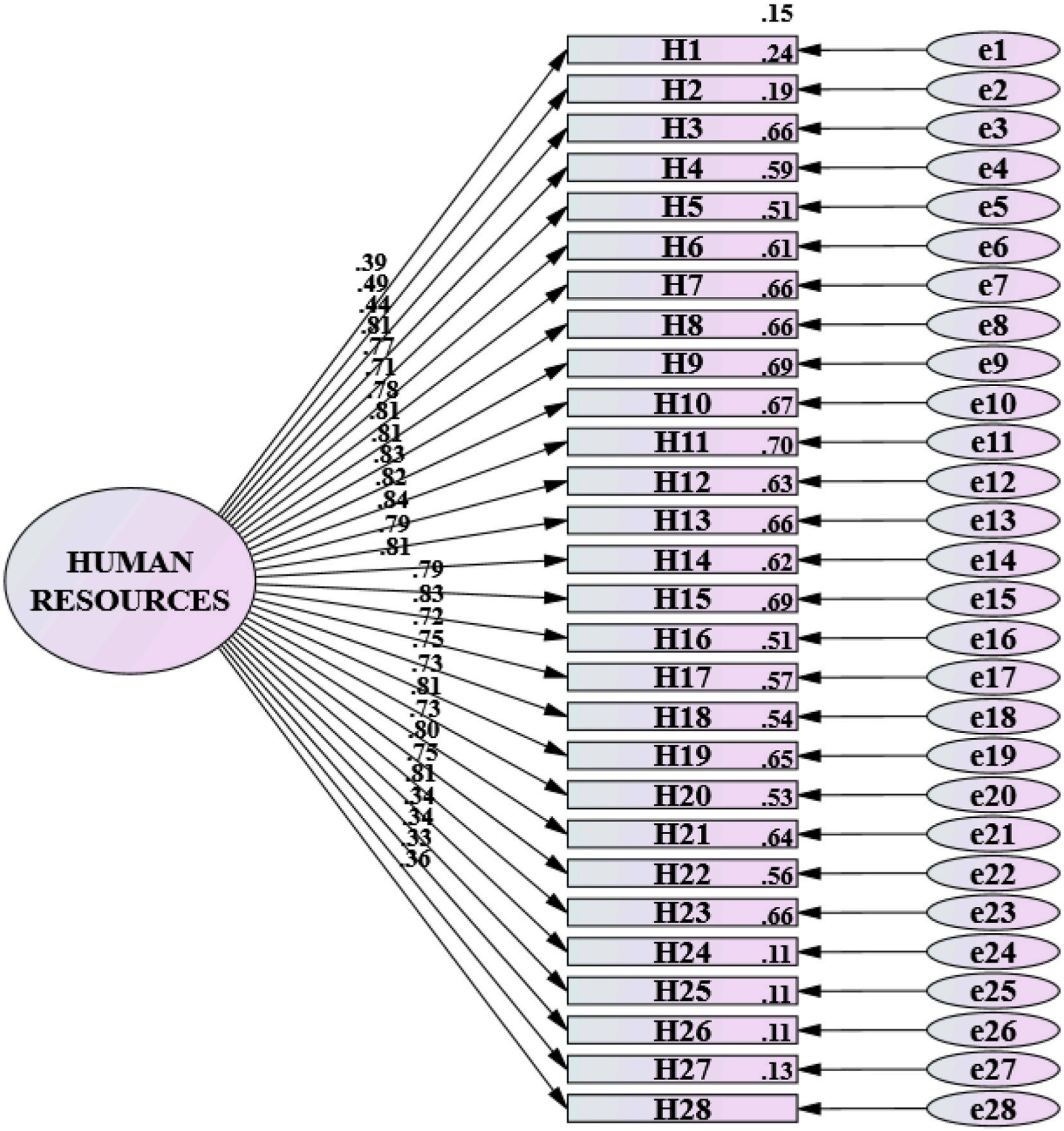

Fig. 3. First-order confirmatory factor analysis of human resource management in standard estimation mode.

4.3.1. First-order confirmatory factor analysis of factors

The employment of the first-order confirmatory factor analysis methodology emerges as an instrument aimed at the validation and substantiation of measurement constructs pertinent to the domain of productivity [41–43]. Within the purview of this research endeavor, said methodology shall be wielded to scrutinize but for three principal factors constructs, namely productivity encompassing a corpus of ten variables, human resource management encompassing twenty-eight variables, and the quality of online communication, embracing twenty-six variables. These constructs have been elucidated graphically through representations (refer to Figs. 2–4) generated by the AMOS software.

4.3.2. Creating the measurement model

A measurement model is created through confirmation factor analysis (CFA) as seen in Figures (2- 4). The model was refined by deleting the elements that showed factor load coefficients less than 0.4 threshold as in Tables (7)–(9) after comparing them with the exploratory factor analysis (EFA) of the elements in Table 6, which resulted in a model consisting of 51 factors as in Fig. 5. The reliability and validity of the model were evaluated by the composite reliability coefficient (CR) and the extracted mean variance (AVE), respectively. The results showed that the CR values for the factors of productivity, human resource management, and internet connection quality were 0.911, 0.973, and 0.957, respectively, indicating high reliability [44,45]. The AVE values for the same factors were 0.539, 0.502, and 0.516, respectively, indicating high validity [46]. The Kaiser-Meyer-Olkin (KMO) sampling sufficiency test was also used to confirm the adequacy of the sample size. The results showed that the KMO value of the face related to the quality of

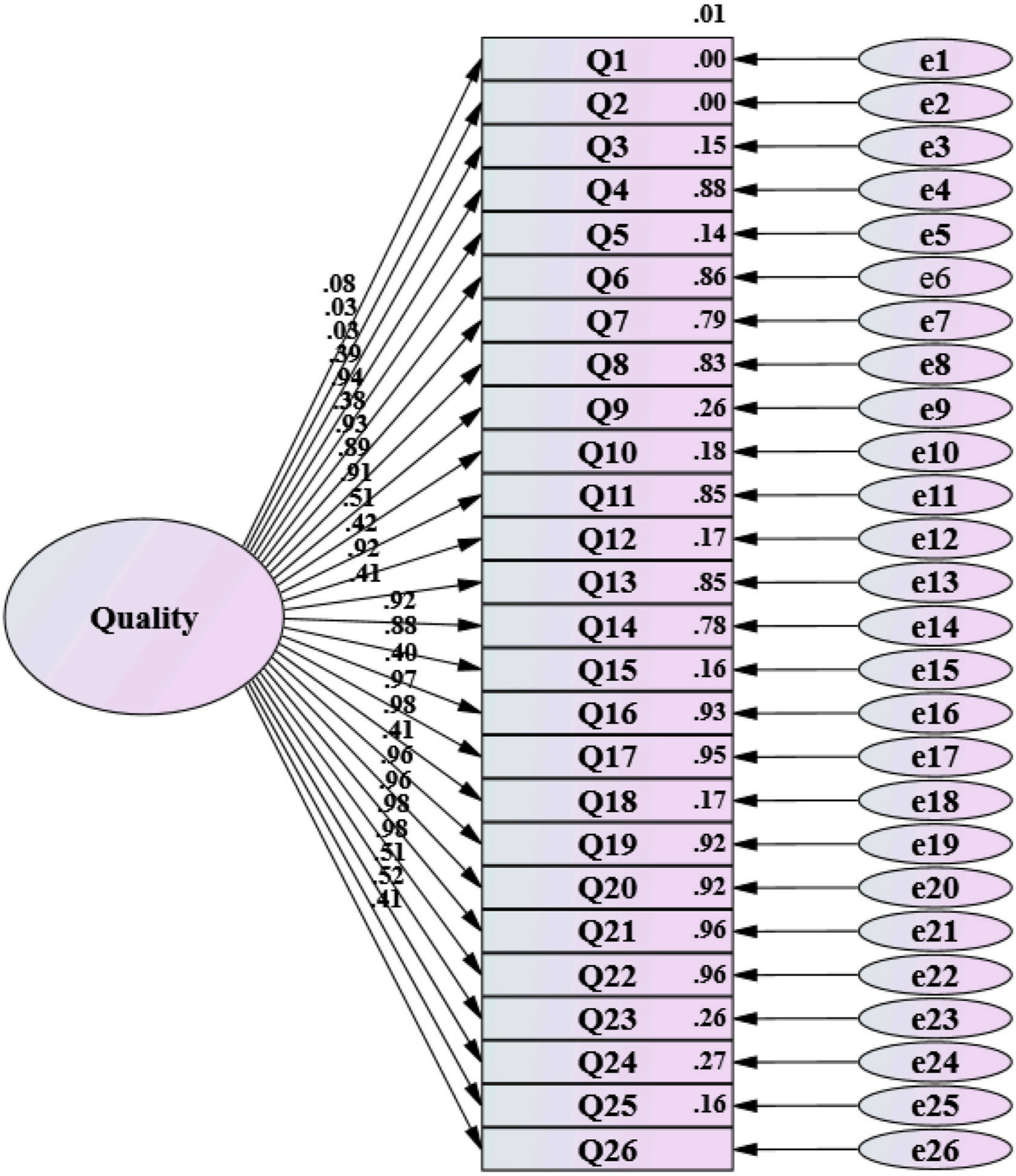

Fig. 4. First-order confirmatory factor analysis of internet connection quality in standard estimation mode.

internet connection was 0.833, which is higher than the specified lower limit of 0.7 [47–50]. Finally, the statistical significance of the relational associations between the explicit variables and the latent variable was evaluated, and all P-values, except those that were omitted, showed resounding statistical significance at a strong confidence level of 99% [51].

4.3.3. Improvement of the measurement model

After drawing the standard model in the Amos program as in Fig. 5, it was found that the value of the root mean square error of the estimate (RMSEA) in Table 10 is equal to 0.188, which is greater than the recommended value of 0.08 [52,53]. This indicates that the mean square of errors of the model is not good and the model is not acceptable. Additionally, the chi-square value of the degree of freedom 9.707 is more than 3, and the GFI, CFI, and NFI indices are less than 0.9, which shows that the structural model of the research variables is inappropriate [54,55].

To improve the model, the following steps can be taken.

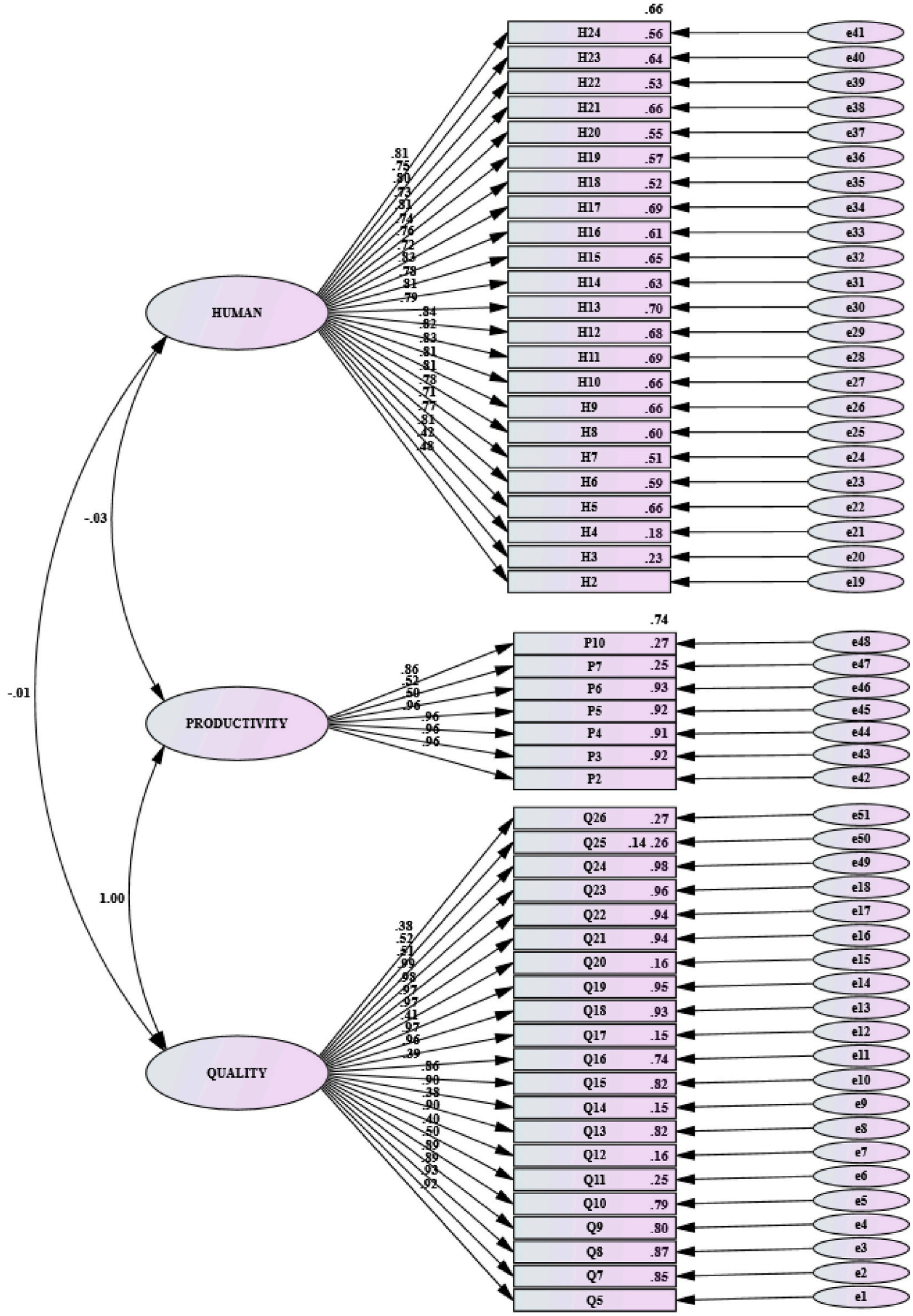

Fig. 5. Path coefficient of the measurement model in the mode of standard coefficients after deleting the factors less than 0.4.

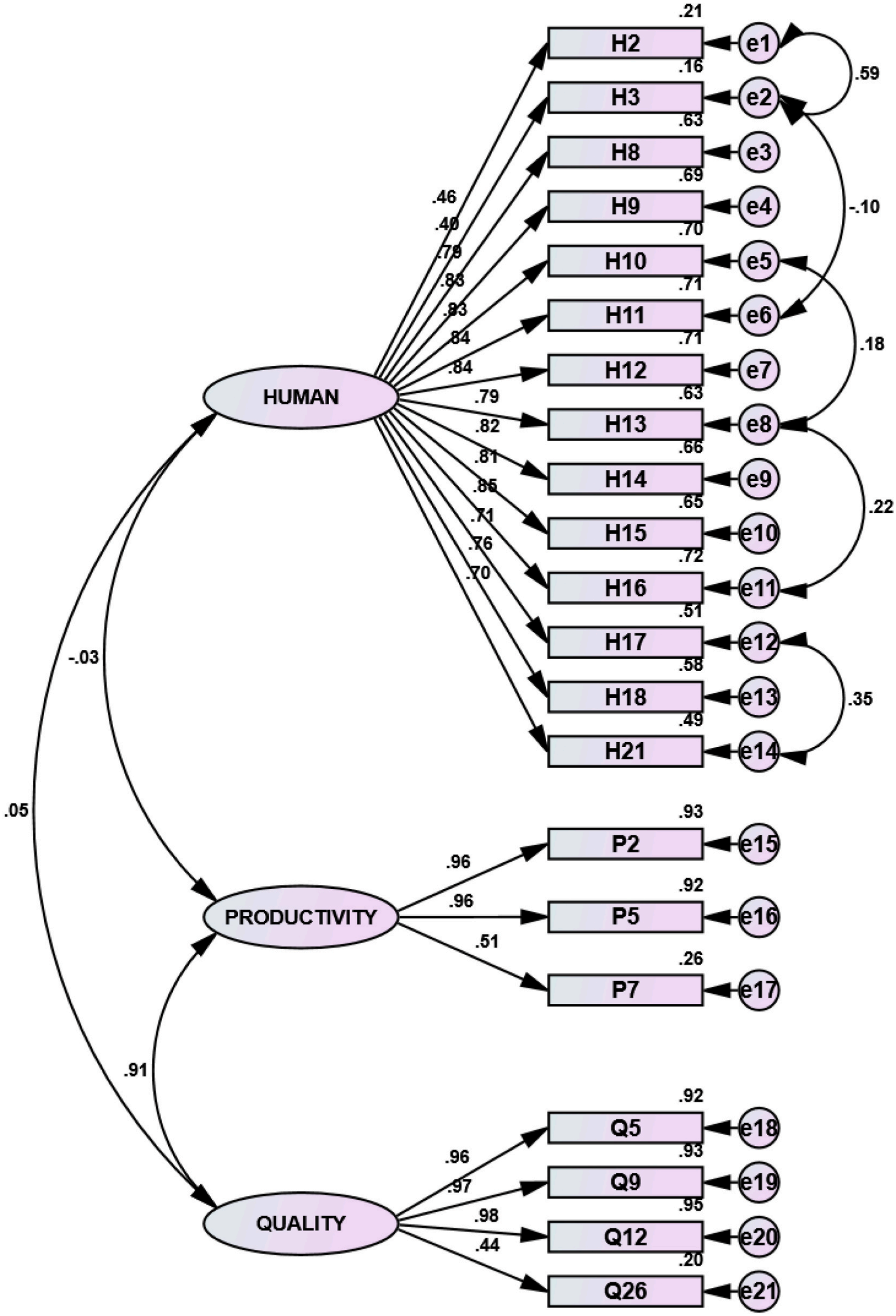

Fig. 6. Path coefficient of the measurement model in the mode of standard load coefficients after improving its model.

- ➢ Select the appropriate model through the text output and the modification indices (M.I.) and from the index on the variance estimation option.
- ➢ Remove the high (M.I.) values between the two variables from one of them with a lower weight.
- ➢ On the estimate option, select the regression weight and from the scales option, select the standard regression weight.
- ➢ Check which variable whose weight is less is removed from the chart, rerun the program, and check all the indicators on the appropriate model (model fit).
- ➢ Iterate this process multiple times until reaching the correct values and accepting the appropriate model, as illustrated in Table 11, where we observe that the RMSEA value equals 0.045. This value, being less than 0.05, signifies a good mean square error (CMIN/DF) for the model, rendering it acceptable (typically falling between 1 and 3). Additionally, the GFI, CFI, and NFI indices exceeding 0.9 indicate the relevance of the model in measuring research variables [58,59].

4.3.4. Model conversion (CFA) of the measurement model to structural model (SEM)

In structural equation modeling (SEM), the measurement model can be converted to a structural model after obtaining an acceptable measurement model, the structural model is represented by arrows and shows the relationships between latent variables, once the structural model is implemented, the load values of the factors do not change [56]. The measurement model is used to measure the relationships between observed variables and latent variables, while the structural model is used to measure the relationships between latent variables [56,57]. The structural model can be analyzed using a confirmatory factor analysis (CFA) or SEM [56–58]. It is important to note that the measurement model and structural model are interdependent and should be developed simultaneously [56,57]. After obtaining an acceptable measurement model, it can be converted to a structural model by representing the relationships between latent variables with arrows, the load values of the factors do not change after implementing the structural model [56].

In summary, the measurement model can be converted to a structural model in SEM after obtaining an acceptable measurement model. The structural model is represented by arrows and shows the relationships between latent variables. The load values of the factors do not change after implementing the structural model. The structural model can be analyzed using CFA or SEM. It is important to develop the measurement model and the structural model simultaneously as shown in Fig. 7 with the results of the AMOS program in Table 12.

It is noteworthy that the results presented in Table 12 exhibit complete similarity to those in Table 11. Consequently, we can assert that the structural model depicted in Fig. 7 is deemed appropriate and acceptable..

5. Results and discussion

Based on the information provided, the structural model in Fig. 7 consists of three factors, with two being independent and one being dependent. The dependent factor relates to the quality of the Internet connection and includes four dependent variables: Q12, Q9, Q5, and Q15. These variables have standard regression weights of 0.98, 0.97, 0.96, and 0.44, respectively, and exhibit a positive and statistically significant influence (refer to Table 13) on project productivity, with a correlation coefficient of 0.92 (refer to Fig. 7).

The independent factor, human resources management, consists of several dependent variables: H16, H12, H11, H10, H9, H14, H15, H13, H8, H18, H17, H26, H2, and H3. These variables are arranged based on their standardized regression weights, ranging from 0.85 to 0.40. All coefficients have a positive orientation and statistical significance, with an impact of −0.7 on productivity. This indicates an inverse relationship between human resource management and construction project productivity, where a decrease in human resource management aspects leads to an increase in productivity dimensions. This relationship is further influenced by the quality of the Internet connection, with an oscillating effect of 0.05.

The dependent variable of productivity comprises three specific dependent variables: P2, P5, and P7, with standard regression weights of 0.96, 0.96, and 0.51. These variables demonstrate a positive and meaningful impact, highlighting the significant influence of Internet communication quality, which surpasses the effects of human resource management. The relationship between productivity and human resource management is inversely related, while the relationship between productivity and Internet communication quality is directly related. The squared multiple correlation (SMC) value is 0.84, indicating a significant portion of variance explained by the predictor variables and a strong association between these predictors and the dependent variable.

5.1. Insights and improvements

The examination yields significant insights, and a judicious recognition of its inherent limitations, coupled with deliberate contemplation on avenues for enhancement, stands to fortify the resilience of the structural model and broaden its applicative scope. Several salient considerations merit attention for the amelioration of insights, elucidated as follows.

- Longitudinal Studies: Conducting longitudinal studies can provide insights into how the relationships evolve over time, capturing dynamic changes.
- Cross-Industry Analysis: Exploring the model across different industries can enhance its applicability and identify industry-specific nuances.
- Qualitative Analysis: Supplementing quantitative findings with qualitative insights can offer a more comprehensive understanding of the identified relationships.

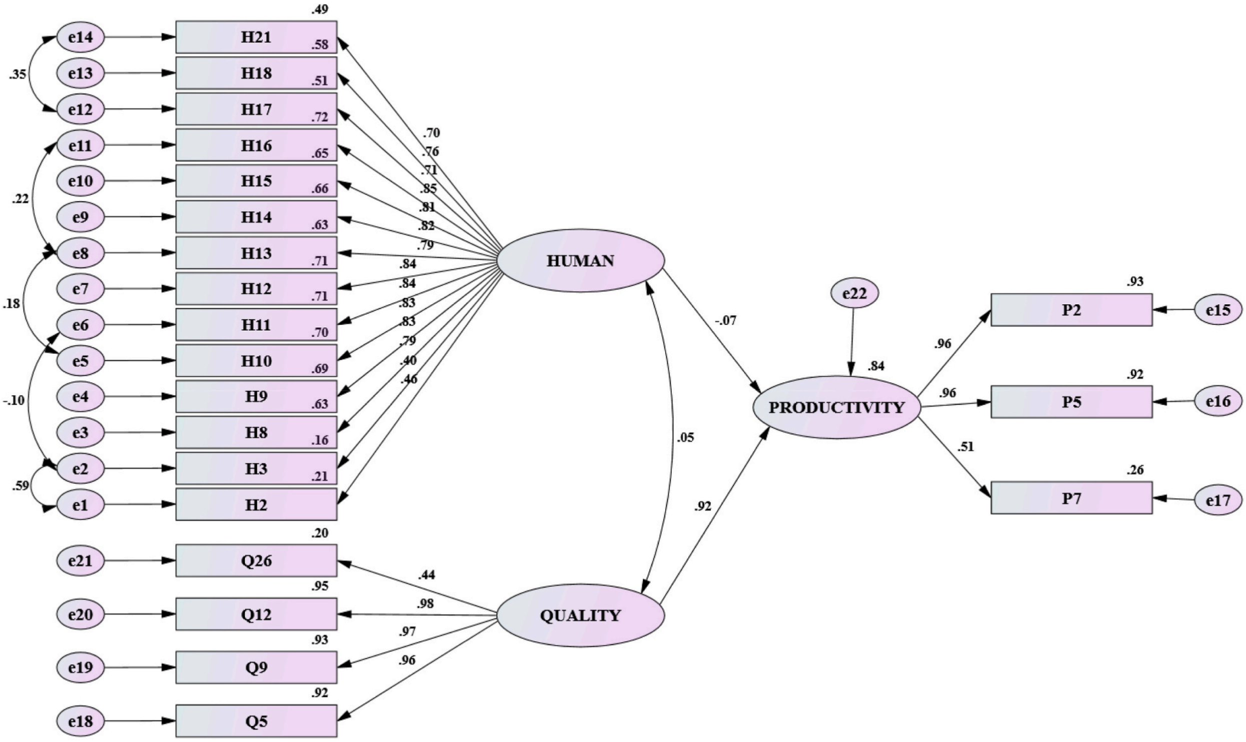

Fig. 7. Structural model in the case of standard factor loading coefficients. Note: All codes have been defined in Tables 14–16.

Table 13
Standardized Regression weights and P-value.

NO.	Variables			Estimate Standardized	P-Value	Result
1	PRODUCTIVITY	<—	HUMAN	−0.075	0.018	*
2	PRODUCTIVITY	<—	QUALITY	0.919	***	✓
3	H2	<—	HUMAN	0.460	***	✓
4	H3	<—	HUMAN	0.403	***	✓
5	H8	<—	HUMAN	0.793	***	✓
6	H9	<—	HUMAN	0.832	***	✓
7	H10	<—	HUMAN	0.834	***	✓
8	H11	<—	HUMAN	0.845	***	✓
9	H12	<—	HUMAN	0.840	***	✓
10	H13	<—	HUMAN	0.795	***	✓
11	H14	<—	HUMAN	0.815	***	✓
12	H15	<—	HUMAN	0.809	***	✓
13	H16	<—	HUMAN	0.851	***	✓
14	H17	<—	HUMAN	0.714	***	✓
15	H18	<—	HUMAN	0.762	***	✓
16	H21	<—	HUMAN	0.698	***	✓
17	P2	<—	PRODUCTIVITY	0.965	***	✓
18	P5	<—	PRODUCTIVITY	0.961	***	✓
19	P7	<—	PRODUCTIVITY	0.514	***	✓
20	Q5	<—	QUALITY	0.961	***	✓
21	Q9	<—	QUALITY	0.966	***	✓
22	Q12	<—	QUALITY	0.976	***	✓
23	Q26	<—	QUALITY	0.443	***	✓

Note: All results are derived from the output of the AMOS program.

Table 14
Codes factors of structural model (work productivity).

No.	Code	Factors
1	P2	The presence of comprehensive operational plans detailing project execution strategies
2	P5	The influence of temperature and climatic variables on project operations.
3	P7	Proficiency in communication skills, the lucidity of directives, and the efficacious exchange of information within the workplace milieu.

Table 15
Codes factors of the structural model (Human Resource Management).

No.	Code	Factors
1	H2	The adoption of Internet communication in human resource management significantly augments the identification of project employees' capabilities by harnessing modern communication networks.
2	H3	Contemporary communication networks not only shape the organizational culture but also empower employees to proactively contribute to project decision-making.
3	H8	Internet communication substantially contributes to ensuring the occupational safety of project workers.
4	H9	Establishing a dedicated department or division specializing in communication and information technology is deemed necessary to facilitate effective project management.
5	H10	The utilization of the Internet enables proactive awareness and mitigation of potential risks before their occurrence.
6	H11	The utilization of modern Internet communication avenues offers the opportunity to engage with higher echelons within the organization, thereby facilitating the development of employees' skills and the enhancement of their overall performance.
7	H12	Project management relies heavily on online platforms for issuing directives and instructions.
8	H13	Meetings between project managers and workers are deemed more effective than issuing orders solely via the Internet.
9	H14	A successful manager possesses the capability and acumen for online communication and the adept use of modern technologies within project management.
10	H15	Based on your experience within the project department, do conventional communication methods, such as paper-based communication, suffice for effective communication?
11	H16	Are engineers and project staff within your organization proficient in the utilization of online communication tools?
12	H17	Do engineers and project staff within your organization possess sufficient proficiency in utilizing Internet communication tools?
13	H18	Does your department or institution employ the Internet as a primary medium for announcing project tenders?
14	H21	Conducting workshops and educational seminars significantly enhances the efficiency of workers in utilizing online communication tools.

Table 16
Codes factors of Structural model (Internet Communication Quality).

No.	Code	Factors
1	Q5	The efficacy of Internet communication quality within human resource management facilitates the seamless dissemination of information, thereby augmenting project productivity.
2	Q9	Distinct projects and companies, regardless of magnitude, necessitate unique Internet applications underpinned by exceptional Internet connectivity quality.
3	Q12	Internet communication quality profoundly contributes to the delineation of responsibilities and authorities, a facet that favorably reverberates upon work productivity within the project context.
4	Q26	Speedy and high-quality Internet applications serve to ameliorate operational issues within the work environment.

Table 17
Study design and sample size determination based on Morgan's Table.

Governorate	Consultants	Project Managers	Engineers (Public/Private Sectors)	Engineers in Government Construction Projects	Sample Size (Morgan's Table)
Wasit	10	7	1300	65	56
Babylon	10	2	2200	85	70
Karbala	5	5	2400	70	59
Najaf	7	–	1500	75	63
Total Sample Size	32	14	6400	295	248

Note: The sample size is determined based on Morgan's Table [28] for each governorate, ensuring a comprehensive and representative participant pool for the study.

- External Variables: Consideration of external variables not included in the current model can contribute to a more holistic understanding of project productivity.

6. Conclusions

In conclusion, the structural model, incorporating dependent variables such as Internet communication quality and Internet

Table 18
Statistical parameters and Definitions.

Statistical Parameter	Definition	Principal Reference
Cronbach's Alpha	Reliability measure for scale items	[59]
Composite Reliability(C.R)	Measure of internal consistency	[60]
KMO	Kaiser-Meyer-Olkin	[61]
AVE	Average Variance Extracted	[62]
p-value	Statistical significance level	[63]
GFI	Goodness-of-Fit Index	[64]
RMR	Root Mean Square Residual	[65]
NFI	Normed Fit Index	[66]
CFI	Comparative Fit Index	[66]
RFI	Relative Fit Index	[67]
IFI	Incremental Fit Index	[65]
PRATIO	Parsimony Ratio	[64]
PCFI	Parsimony Comparative Fit Index	[64]
RMSEA	Root Mean Square Error of Approximation	[68]
CMIN/DF	Chi-Square divided by Degrees of Freedom	[69]
ICT	Information and communications technology	[70]

communication in human resources management, along with their respective factors influencing the independent variable of productivity, robustly elucidates the dynamics of dependent changes. The analysis underscores that enhancements in Internet communication in human resources management significantly bolster the quality of Internet communication within construction projects. Notably, the factors associated with Internet communication quality exert a more pronounced influence on work productivity compared to those linked to Internet communication in human resources management.

However, a crucial observation emerges, indicating an inverse relationship between the latter factors and work productivity. This implies that efforts to enhance human resources management within the realm of Internet communication may paradoxically result in a decrease in work productivity. This paradox warrants careful consideration in the formulation of strategies aimed at optimizing communication and human resources management practices in construction projects.

6.1. Limitations of the study

It is imperative to acknowledge certain limitations inherent in this study. The scope primarily focuses on specific governorates in Iraq, potentially limiting the generalizability of findings to the broader construction sector. Additionally, the study's cross-sectional nature provides a snapshot, and longitudinal studies could offer a more comprehensive understanding of the evolving relationships over time.

6.2. Outlook on future research

Future research endeavors should consider expanding the geographical scope, encompassing diverse regions and cultural contexts. Longitudinal studies could capture dynamic shifts in Internet communication, human resources management, and productivity relationships. Furthermore, investigations into nuanced factors influencing the observed paradoxical relationship between human resources management in Internet communication and work productivity would be valuable.

6.3. Impact and benefit

The presented study offers valuable insights into the intricate relationships between Internet communication, human resources management, and work productivity in construction projects. Practically, the findings can guide project managers and policymakers in optimizing communication strategies and human resources practices, thereby fostering enhanced project productivity. This study's impact lies in its potential to inform targeted interventions and improvements in construction project management practices in the Iraqi context.

6.4. Conclusion significance

In conclusion, this study contributes substantively to the existing body of knowledge, shedding light on nuanced dynamics within construction projects. The identified paradox underscores the need for a nuanced approach in formulating strategies that balance advancements in human resources management with the potential impacts on work productivity. This study stands as a foundation for further research and practical interventions aimed at fostering efficiency and success in construction projects not only in Iraq but also in similar contexts globally.

6.5. Acknowledging limitations and methodological considerations

The structural model enhances our understanding of Internet communication, human resources management, and work productivity in construction projects, it's crucial to acknowledge certain limitations.

6.5.1. Structural model

- **Limitation Acknowledgment**: The model, though robust, may not capture all complexities. Acknowledging this adds transparency to the study's scope.
- **Methodology Note**: While providing quantitative insights, qualitative dimensions may be overlooked. Future research could explore mixed methods for a comprehensive analysis.
- **Potential Limitation**: Focusing on specific variables may limit the model's applicability. A broader exploration could offer a more nuanced understanding.

6.5.2. Internet communication quality and human resources management

- **Limitation Acknowledgment**: Generalizing findings to diverse projects requires caution due to potential variations in human resources management strategies.
- **Methodology Note**: Qualitative aspects of communication quality could be further explored in future research for a holistic understanding.
- **Potential Limitation**: The inverse relationship between human resources management and productivity demands exploration for a deeper understanding.

6.5.3. Productivity

- **Limitation Acknowledgment**: Specific variables contribute to productivity, but excluding others introduces potential limitations.
- **Methodology Note**: Quantitative measures, while clear, may not capture all dimensions. Exploring additional measures could enhance the analysis.
- **Potential Limitation**: The inverse relationship between certain human resources management factors and productivity introduces complexity, requiring acknowledgment for nuanced interpretation.

By recognizing these limitations and methodological considerations, this study aims to uphold transparency and contribute to future research endeavors in the construction project domain.

7. Gratitude for all participants

"We extend our profound appreciation to the governmental departments and institutions across the governorates of Wasit, Babylon, Karbala, and Najaf for their invaluable contributions to this research undertaking. Their unwavering cooperation and support have played a pivotal role in the seamless execution of this study. Their steadfast commitment to advancing the domain of construction project management and their dedicated efforts to enhance our comprehension and development of the project workforce are held in high regard. Their enthusiastic engagement has significantly enriched the scope and depth of our research, and we eagerly anticipate further collaboration in the pursuit of innovative insights and solutions for the successful execution of projects within the country."

Data availability statement

Data will be made available upon request.

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Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Khaldoon Faris Qani Al-aloosy: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sajjad Mirvalad:** Supervision, Methodology. **Naser Shabakhty:** Supervision, Methodology.

Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e28500.

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