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Ala'a Saleh Alshdiefat*

ISM model for assessing critical productivity factors in the Jordanian construction industry post-COVID-19 pandemic

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Abstract: The construction industry is a human-intensive industry despite the massive development in technologies. Nowadays, after crossing COVID-19 pandemic, the construction industry is an important sector for saving the national economy. The COVID-19 pandemic has created new ways of thinking due to massive and unpredictable socioeconomic consequences. Thus, understanding the critical productivity factors after the COVID-19 pandemic will enhance the construction industry by improving the understanding of the professionals who are involved at an early stage of the project lifecycle. This study aims to determine the critical productivity factors after the COVID-19 pandemic for enhancing the construction industry in developing countries such as Jordan. A review of available literature similar to the related topics before the COVID-19 pandemic was explored, and then a questionnaire was distributed across the Jordanian construction industry to determine the main productivity factors post-COVID-19 pandemic. A focus group was used to determine the interrelationship among the factors with the Interpretive Structural Modelling (ISM) approach. The obtained results indicated that 22 main productivity factors affected the Jordanian construction industry. The hierarchy of these factors is categorised into six levels of ISM whereas the sixth level has the greatest factors that influence productivity in the construction industry. Thus, enhancing productivity in construction projects requires solving problems related to factors in level 1, which will help to solve problems at the next level and so on.

Keywords: construction, productivity, factors, Jordan, post-COVID-19 pandemic

***Corresponding author: Ala'a Saleh Alshdiefat,** Department of Civil Engineering, Faculty of Engineering and Technology, Philadelphia University, Amman, Jordan, E-mail: alaasms2002@gmail.com

1 Introduction

The contribution of the construction industry to the economy and employment is significant for both developed and developing countries. It drives the continuous development of the global economy (Alshdiefat et al. 2023). For example, the construction industry in the UK employs 2.4 million people and is worth over £100bn, (Rhodes 2019). However, the COVID-19 pandemic put massive pressure on productivity in construction projects where the lockdown directly affects the construction process. Sihombing et al. (2020) indicated that the construction phase is the most impacted in the overall project life cycle during the pandemic. It has affected the labourers emotionally, mentally, physically and financially, resulting in a massive impact on their well-being. In terms of productivity in construction projects, the pandemic significantly reduces labour productivity and causes huge losses (Quezon and Ibanez 2021).

Nowadays, after the COVID-19 pandemic, the importance of the construction industry has spurred resulting in to improvement of this sector. According to Bsisu (2020), the construction industry plays a significant role in saving the national economy after the control of COVID-19. It is a vital sector for stimulating the post-COVID economy. The growth of the construction industry after the COVID-19 pandemic requires increased productivity to ensure the successful delivery of new projects (Anditiaman et al. 2019). However, there are limited studies investigating the productivity factors post-COVID-19 pandemic. Thus, understanding the crucial productivity factors after the COVID-19 pandemic will increase the productivity of construction projects by improving the understanding of the professionals who are involved at the early stage of the project lifecycle. In this regard, the COVID-19 pandemic creates a new way of thinking across the globe due to massive and unpredictable socioeconomic consequences. Karin et al. (2020) highlighted the importance of developing an integrated plan for the post-lockdown period. This study complies with this orientation for developing a new plan for productivity within construction projects post-COVID-19 periods by interpretive structural modelling (ISM) approach for the vital productivity factors. It aims to determine the crucial productivity factors post-COVID-19 pandemic for improving the construction industry in developing countries such as Jordan. The study's findings will help to highlight significant productivity factors in the building sector to improve productivity and be ready for any new wave or new health pandemic that could occur. It identifies the main productivity factors by developing the ISM model which ensures delivering construction projects successfully.

2 Literature review

The productivity in the construction industry is considered very weak and does not match the growth where it has grown by only 1% over the last 20 years (Barbosa et al. 2017). Productivity is a significant issue in the construction industry. The high productivity performance reflects rising profits and producing competitive products (Kasih and Adi 2019). According to Kasih and Adi (2019), actors in the construction industry within developing countries must increase their productivity to match the competition in the construction world. So, it is necessary to identify the main productivity factors in the Jordanian construction industry to enhance productivity.

2.1 Productivity factors

The productivity in construction projects depends on a wide range of factors and identifying the critical factors that are essential for improving and sustaining the construction sector is crucial. Numerous researchers examined productivity factors and categorised them in different countries. Mahamid (2013) found that 'workforce experience and skills, lack of communication between project parties, poor relation between managers and employees, schedule delay and remuneration timeless are the main top factors' in construction projects. In Qatar, Jarkas and Bitar (2012) identified the critical factors that affect labours productivity as 'supervision, labour skills, lack of materials, lack of experienced labour, communication, shortage of leadership of construction managers, high-temperature, delays in responding to "Requests For Information", shortage of providing labour with transportation and percentage of work subcontracted'. Alaghbari et al. (2019) classified 53 factors into four main categories: human, management, technical and external. Hasan et al. (2018) added 'The poor communication, misunderstanding, lack of clarity of instruction and technical specifications, lack of coordination, delay in response and slow decision making are significant factors impede productivity in construction projects in developed and developing countries'. In Bahrain, Jarkas (2015) grouped 37 factors into four categories: Management, technology, labour and external. Hiyassat et al. (2016) determined 27 factors influencing construction labour productivity. They classified these factors based on dimensions such as 'creating a plan, the relations between craftsman and managers, education levels and labour experience, climate conditions, adopted technology, labour motivation, safety conditions, worker personal problems and impact of religion'. Quezon and Ibanez (2021) categorised 53 factors affecting road construction projects into seven main groups with sub-related factors based on their similarity to supervision, health and safety, workforce, schedule compression, material and equipment, motivation and management group. In Jordan, Hiyassat et al. (2016) indicated that the Jordanian construction industry faces a significant lack of productivity levels, which is reflected in delays in completion and cost overruns in construction projects (Sweis et al. 2008; Abu Hammad et al. 2010; Mattarneh 2015). The main productivity factors that affect construction projects are poor planning and scheduling, material shortage on the project site, equipment shortage, lack of skilled labour and poor site management (Bekr 2016). The significant cluster of productivity factors are planning, worker management relationship, education and experience, technology and equipment and motivation. However, the safety, worker status and religion effects are the least important dimension (Hiyassat et al. 2016). A study by Alabbadi and Agyekum-Mensah (2017) indicated the main motivational factors affecting working productivity in construction sites in two main cities (Amman and Aqaba) are personal growth/career improvement, payment on time and decision-making ability. These factors and clusters provide a clear image of the main factors that affected the productivity in the Jordanian construction industry before the COVID-19 pandemic. However, it does not clarify the current situation post-COVID-19 pandemic, as well it does not identify the interrelationship between barriers. Therefore, this research focuses on identifying the critical productivity factors in Jordanian construction projects post-COVID-19 pandemic.

2.2 Impact of COVID-19 on productivity

The COVID-19 pandemic massively affects productivity in construction projects. According to Quezon and Ibanez

(2021), the staff in construction sites such as project engineers, site engineers and supervisors could face difficulties in understanding how to achieve good productivity during the pandemic. According to Biswas et al. (2021), the pandemic reduces the productivity of construction projects due to labour shortages and disruption of transportation because of the lockdown and disruption of the supply chain of materials to the construction site. Hesna et al. (2021) indicated the COVID-19 pandemic's fundamental disruption of the construction industry in Indonesia.

Traditionally, construction projects in Jordan depend on field labour who deliver raw materials and production materials to the building sites and then use them during construction processes with the assistance of equipment and tools. The COVID-19 pandemic caused an abrupt stoppage of onsite construction works in Jordan due to restrictions on labour movement. The short-term impacts of the COVID-19 pandemic were observed on construction projects through increased costs and delays. However, the long-term impacts should be identified to propose effective solutions to mitigate them. Bsisu (2020) indicated the future results of the COVID-19 pandemic will be in terms of loss of jobs by skilled civil engineers, financial problems for construction firms and legal implications due to delays in projects. These expected results significantly affect the productivity of construction projects in Jordan. So, this study focuses on identifying the critical productivity factors after the Pandemic.

3 Methodology

This study was conducted to explore the critical productivity factors post-COVID-19 pandemic in developing countries such as Jordan. Therefore, a suitable procedure for data collection was adopted to generate useful data and ensure achieving a meaningful research conclusion that contributes to the existing knowledge. The mixed method investigations, quantitative followed by qualitative are used to determine the critical productivity factors post-COVID-19 pandemic. The combination of quantitative and qualitative methods is a very powerful way to gain results and draw conclusions related to the productivity factors post-COVID-19 pandemic. This research adopted a mixed methods approach which integers statistical data with focus group discussion. Triangulation improves the validity of research by collecting data from multiple sources to ensure that the data is consistent (Saunders et al. 2016).

A critical literature review for a similar topic covering various developed and developing countries was conducted to explore the main productivity factors within the construction industry. A questionnaire was designed based on the literature review results of productivity factors in construction projects. The obtained results formulated the questionnaire has two parts: the first part contains general information about the participants. The second part asked to determine the critical productivity factors from 50 productivity factors obtained from the literature review analysis. A pilot study was used for the final draft of the questionnaire before being distributed. The researcher asked pilot respondents to answer questions, provide feedback on the questionnaire design and content and show whether the questionnaire produced information related to the research subject. Thus, the questionnaire was pilot-tested for clarity and appropriateness in a self-administrative pre-test with six experts in the Jordanian construction sector. Based on the pilot study, some items were eliminated and others were modified. The respondents evaluated these factors based on their influence on the Likert Scale from 1 to 5, where 1 means the factor is not important and 5 means it is very important. In the subsequent stage, the focus group was conducted to determine critical productivity factors in construction projects post-COVID-19 pandemic and define their interrelationships. The focus group was used to facilitate the interpretation of obtained quantitative results (Stewart and Shamdasani 2014). Several researchers offer views on the number of participants in a focus group such as Krueger and Casey (2014) who suggested five to eight participants which is appropriate to control the discussion and allow participants to present their opinions freely. In this research, the researcher invited seven experts to participate in the focus group used for the validation of the questionnaire results and to develop the ISM model. The number of participants was based on Krueger and Casey (2014) suggestion to facilitate the discussion and let the researcher control the discussion and collect key points. The participants are selected based on their knowledge and experience within the Jordanian construction industry. Seven participants contributed to the focus group as follows: one from academic sectors with 13 years of experience, two contractors with 15- and 17 years of experience, respectively, three engineers with 20-, 19- and 15-years of experience, respectively, and one construction manager from CM company with 25 years experience. The ISM approach is considered an effective technique because of its ability to deal with the complexity of relationships involving many indicators (Mathiyazhagan and Haq 2013). The ISM approach enables to development of a map of the multi-relationship between several factors. The ISM approach is widely used to determine the interrelation between critical factors (Marinelli et al. 2022). Thus, this research uses the ISM approach to determine the critical productivity factors in the post-COVID-19 pandemic in Jordan. The focus group constructs ISM based on the obtained results from analysing the questionnaire. During the construction ISM model, the focus group agreed to use only factors with means three or higher which were considered above the neutral position on the Likert Scale. Thus, 22 factors were used to construct the ISM model for the critical productivity factors in the Jordanian construction industry post-COVID-19 pandemic.

4 Results and discussion

4.1 Questionnaire reliability

The reliability was conducted for the responded questionnaires by Cronbach's alpha on a scale of 0%–100%. The higher value means more consistent responses and significant reliability. The minimum accepted value is 0.70 which means that the answers are reliable and concluded valid and reliable results (Alshdiefat 2018). The Cronbach's alpha for the productivity factors was 0.936 which is considered significant reliable and consistent.

4.2 Respondents' backgrounds

The first part of the questionnaire included general information about the respondents: Education, Organisation and Experience. The Majority of respondents 197 out of 267 have a Bachelor's degree in engineering (73.8%). This is followed by 43 (16.1%) participants having master's degrees, 16 (6.0%) participants having diplomas in engineering and 11 (4.1%) respondents having PhD in engineering. Similarly, 109 (40.8%) respondents are working for an engineering company and 53 (19.9%) respondents are working in government, followed by 49 (18.4%) contractors, 29 (10.9%) clients and 27 (10.1%) suppliers. The questionnaire analysis shows a third of respondents 88 (33%) have 16–20 years of experience, followed by 64 (24%) with 11–15 years of experience, 47 (17.6%) with >20 years of experience, 35 (13.15%) with 6–10 years experience and 33 (12.45) with 0–5 years experience. The variety of education, organisations and experience provide reliable and valid results within the Jordanian construction industry.

4.3 Main productivity factors in Jordanian construction projects

The mean analysis was used to rank the 50 productivity factors based on their influence as shown in Table 1.

The obtained results indicated that Material shortage is the highest factor influencing productivity in Jordanian construction projects with a mean of 3.7 out of 5. This could refer to the massive investment in construction sectors and global shipping disruption of raw materials and tools in the meantime. Lack of empowerment ranked as the second critical factor with means (3.51). Late payment of salary (3.49), Poor communication and coordination (3.49), Improper planning and scheduling of work (3.48), Variation in orders (3.43), Lack of skill and experience of the Workers (3.41), Poor work planning (3.40), Lack of on-site cleanliness (3.38) and Low salary (3.37) are the main 10 critical factors which influence the

Tab. 1: Ranked main productivity factors post-COVID-19 pandemic in Jordanian construction projects.

Factor	Description	Mean	Std. deviation
P26	Material shortages	3.70	1.226
P3	Lack of empowerment (training/seminar)	3.51	1.249
P37	Late payment of salary	3.49	1.258
P40	Poor communication & coordination	3.49	1.330
P44	Improper planning & scheduling of work	3.48	1.212
P43	Variation in orders	3.43	1.116
P6	Lack of skill and experience of the Workers	3.41	1.203
P47	Poor work planning	3.40	1.208
P49	Lack of on-site cleanliness	3.38	1.227
P33	Low salary or underpaid	3.37	1.220
P41	Lack of leadership skill	3.36	0.929

Continued

Tab. 1: Continued.

Factor	Description	Mean	Std. deviation
P16	Lack of drawings availability, drawing errors, slow response to questions withdrawing	3.33	1.156
P36	Little or no financial rewards	3.28	1.191
P25	The poor condition of equipment and tools	3.26	1.197
P22	Workers adherence to safety measures and infection control	3.22	1.199
P27	Low quality of raw material	3.11	1.299
P19	Awareness of COVID-19 protocol	3.10	1.277
P2	Weather conditions	3.09	1.088
P1	Utilising traditional construction methods instead of modern technology	3.05	1.279
P29	Poor arrangement of materials	3.03	1.119
P31	Lack of appropriate equipment when needed or availability of inadequate equipment	3.02	0.994
P32	Lack of Materials when needed due to poor planning or delays in delivery times	3.02	1.234
P9	Changing instruction order	2.98	1.259
P46	Misunderstanding between the agency & contractor	2.98	1.300
P42	Lack of periodic meetings with labourers	2.93	1.385
P18	Improper observance of COVID-19 protocols	2.80	1.219
P50	Regulation and law	2.80	1.231
P38	Poor relations between labours and supervisors	2.76	1.203
P34	Lack of labour recognition	2.75	1.196
P23	Applicability to fully implicate social distancing in their workplace	2.73	1.122
P5	Poor relations among workers	2.57	1.159
P4	Low labourer’s morals/commitment	2.48	1.209
P17	Unsafe working conditions	2.48	1.316
P21	Accident awareness	2.48	1.215
P24	There is a proper use of PPE	2.45	1.280
P12	Changing of foreman	2.44	1.189
P45	Construction managers lack Leadership	2.41	1.319
P11	Poor or no supervision methods	2.30	1.239
P14	Supervisors’ absenteeism	2.27	1.279
P15	There is no mismatch between employee abilities and job demands	2.26	1.222
P8	Depend on hiring and employment of unskilled workers	2.25	1.192
P35	Lack of place for eating and resting	2.24	1.080
P28	Improper material storage location	2.21	1.137
P39	Lack of labour surveillance	2.21	1.316
P10	Inspection delay	2.20	1.183
P30	Lack of availability of required tools and machinery	2.18	1.259
P48	Overcrowded work areas	2.17	1.092
P20	Poor health of workers	1.92	1.169
P7	Increase in labourers’ age (above 40 years)	1.79	0.918
P13	Unskilled supervisors	1.69	0.769

PPE, personal protective equipment.

productivity of construction projects. The results show 22 factors have a mean of 3.0 or above and this means they are the main productivity factors post-COVID-19 pandemic in construction projects. The other 28 factors have a mean value <3.0, so they are not the main factors that could significantly influence productivity. The obtained results indicated a similarity of the critical factors pre- and post-COVID-19 pandemic in the Jordanian construction industry with some differences. For example, the shortage of material is the most significant barrier due to the delayed import of some resources. In total, 22 factors are critical factors in comparison to only 11 factors pre-COVID-19 pandemic (Bekr 2016). Additionally, several factors related to the safety cluster are significant factors post-COVID-19 pandemic.

4.4 ISM model for the critical productivity factors in Jordanian construction projects

The ISM model is suitable for determining the critical productivity factors within construction projects post-COVID-19 pandemic. It is based on a hierarchy that categorises the productivity factors and identifies the interrelation between factors. Several researchers, such as Jung et al. (2021), Marinelli et al. (2022) and Alshdiefat (2018), have used the ISM approach to determine critical barriers affecting the sustainability of construction projects and the effectiveness of construction management. The focus group agreed to construct the ISM model based on the results of the analysis of the questionnaire. Thus, only 22 productivity factors out of 50 factors were considered for constructing the ISM mode. These factors will have a mean value of 3.0 or above which means that they have a significant influence on productivity in construction projects. The following sub-sections illustrate the process of construction ISM model.

4.4.1 Formation of structural self-interaction matrix (SSIM)

The SSIM presents the pairwise interrelationship between productivity factors. Thus, four symbols are used to identify this relation as follows.

V: Barrier *i* influences barrier *j*
A: Barrier *j* influences barrier *i*
X: Barriers *i* and *j* influence each other
O: there is no relation between Barriers *i* and *j*.

4.4.2 Formation of reachability matrix

The Reachability Matrix is developed from the SSIM by transforming each cell of SSIM to binary digit 0 or 1. The transformation is performed by substituting the symbols V, A, X and O with 0 or 1 as follows:

1. If the cell (*i*, *j*) has 'V', then it will change to '1' and the cell (*j*, *i*) is converted to 0
2. If the cell (*i*, *j*) has 'A', then it will change to '0' and the cell (*j*, *i*) is converted to '1'
3. If the cell (*i*, *j*) has 'X', then it will change to '1' and the cell (*j*, *i*) is converted to '1'
4. If the cell (*i*, *j*) has 'O', then it will change to '0' and the cell (*j*, *i*) is converted to '0'.

The focus group checked the transitivity between productivity factors in the reachability matrix. 'Transitivity' means that if there is a straight relationship between A and B and if there is a straight relationship between B and C, then A has a relationship with C. In the focused group, the transitivity was checked concurrently with the formulation SSIM step.

4.4.3 Forming the reachability set, antecedents set and integrations

In this stage the reachability set, antecedents set and intersections are constructed for the productivity factors based on the outcomes of the reachability matrix, as illustrated in Table 2. The level of the productivity factor is determined based on the intersections of the reachability set and antecedent set. The bottom-level indicators will not lead to the other indicators. Once the bottom level of the productivity factor is identified, then it is set aside and not included in further hierarchical analysis. The process is iterated until the level of each productivity factor has been determined. The process of identifying levels within these sub-groups is completed in six iterations where the final level is presented in Table 3. The top level includes a Lack of empowerment (training/seminar), Poor communication and coordination, Workers will adhere to safety measures and infection control policy and Utilising traditional construction methods instead of modern technology. This means it has a significant influence on the productivity of construction projects post-COVID-19 pandemic. Therefore, improving these factors will significantly improve the progress of construction projects in terms of schedule and cost. The lowest level includes five factors: Late payment of salary, Lack of on-site

Tab. 2: Formation of SSIM.

	P26	P3	P37	P40	P44	P43	P6	P47	P49	P33	P41	P16	P36	P25	P22	P27	P19	P2	P18	P29	P31	P32
P26	X	O	O	X	A	A	A	X	O	O	A	O	O	O	O	A	O	A	O	A	O	O
P3		X	O	X	X	X	X	V	V	X	A	V	X	O	X	O	X	O	X	V	V	V
P37			X	O	A	A	O	A	O	O	A	O	O	A	O	O	O	O	O	O	O	O
P40				X	X	X	X	X	V	O	A	V	O	O	X	O	O	O	X	V	V	V
P44					X	V	A	X	O	O	A	X	O	O	O	O	O	O	O	V	V	V
P43						X	O	A	O	A	O	A	O	O	O	A	O	A	O	O	O	O
P6							X	V	V	O	X	V	O	O	V	O	V	O	V	V	O	V
P47								X	V	O	A	V	O	O	O	O	O	O	O	V	O	V
P49									X	A	O	A	O	A	O	O	O	A	O	A	O	O
P33										X	O	V	O	O	O	O	O	O	O	V	O	O
P41											X	O	V	O	V	O	V	O	V	V	V	O
P16												X	O	A	O	O	O	O	O	O	O	O
P36													X	O	O	O	O	O	O	O	O	O
P25														X	O	V	O	O	O	V	X	X
P22															X	O	A	O	X	O	O	O
P27																X	O	A	O	A	A	A
P19																	X	O	V	O	O	O
P2																		X	O	V	O	O
P1																			X	O	O	O
P29																				X	A	A
P31																					X	X
P32																						X

SSIM, structural self-interaction matrix.

Tab. 3: The final levels of sustainable transportation indicators after six iterations.

Factors	Factor name	Level
P3	Lack of empowerment (training/seminar)	6
P40	Poor communication & coordination	
P22	Workers will adhere to safety measures and infection control policy	
P1	Utilising traditional construction methods instead of modern technology	
P44	Improper planning & scheduling of work	5
P47	Poor work planning	4
P26	Material shortages	3
P43	Variation in orders	
P6	Lack of skill and experience of the workers	
P25	The poor condition of equipment and tools	
P31	Lack of appropriate equipment when needed or availability of inadequate equipment	
P32	Lack of materials when needed due to poor planning or delay in delivery times	
P33	Low salary	2
P41	Lack of leadership skill	
P16	Lack of drawings availability, drawing errors, slow response to questions withdrawing	
P36	Little or no financial rewards	
P19	Awareness of COVID-19 protocol	
P37	Late payment of salary	1
P49	Lack of on-site cleanliness	
P27	Low quality of raw material	
P2	Weather conditions	
P29	Poor arrangement of materials	

cleanliness, Low quality of raw material, Weather conditions and Poor arrangement of materials. This means even though these factors are the main factors of productivity they have the lowest influence on construction progress and productivity. Figure 1 shows the ISM model after removing the transitive links based on the relations given in the reachability matrix.

The final model of the ISM approach presents the hierarchy of productivity factors in Jordanian construction projects. The importance of ISM is to establish a contextual association among the various levels of productivity factors. Additionally, the ISM model determines the level of complexity and interrelationship between these factors which should help project managers and construction companies in Jordan and other developing countries similar to Jordan. The hierarchy explains the influence of each factor on the project's progress in terms of productivity. The factors at level 1 have the lowest influence on productivity in construction projects, while those at level 6 have the greatest influence. Therefore, to improve productivity in construction projects, there is a need to solve problems related to factors in level 1, which will help to solve problems at the next level and so on. The obtained results highlighted four critical productivity factors in level 6, one in level 5, one in level 4, six in level 3, five in level 2 and five in level 1.

4.4.4 Classification of factors using MICMAC analysis

The MICMAC principle is used to identify the power of productivity factors. According to Alshdiefat (2018), 'the MICMAC is a powerful tool for the analysis of driving (independent) power and dependent power of the barriers of adopting BIM in the Jordanian construction industry', so it is suitable for this study. Therefore, after the construction of the reachability matrix, the independent and dependent powers were recognised. The independent factors are indicated by the summation value '1' in the row for each related component, while the dependent indicators are indicated by the summation '1' value of the column for each related component. Figure 2 classified the productivity factors into four groups based on their driving and reliance power. The MICMAC analysis, Figure 2, classified the productivity factors in the Jordanian construction industry based on its power to four clusters: 'autonomous', 'dependent', 'linkage', and 'independent',

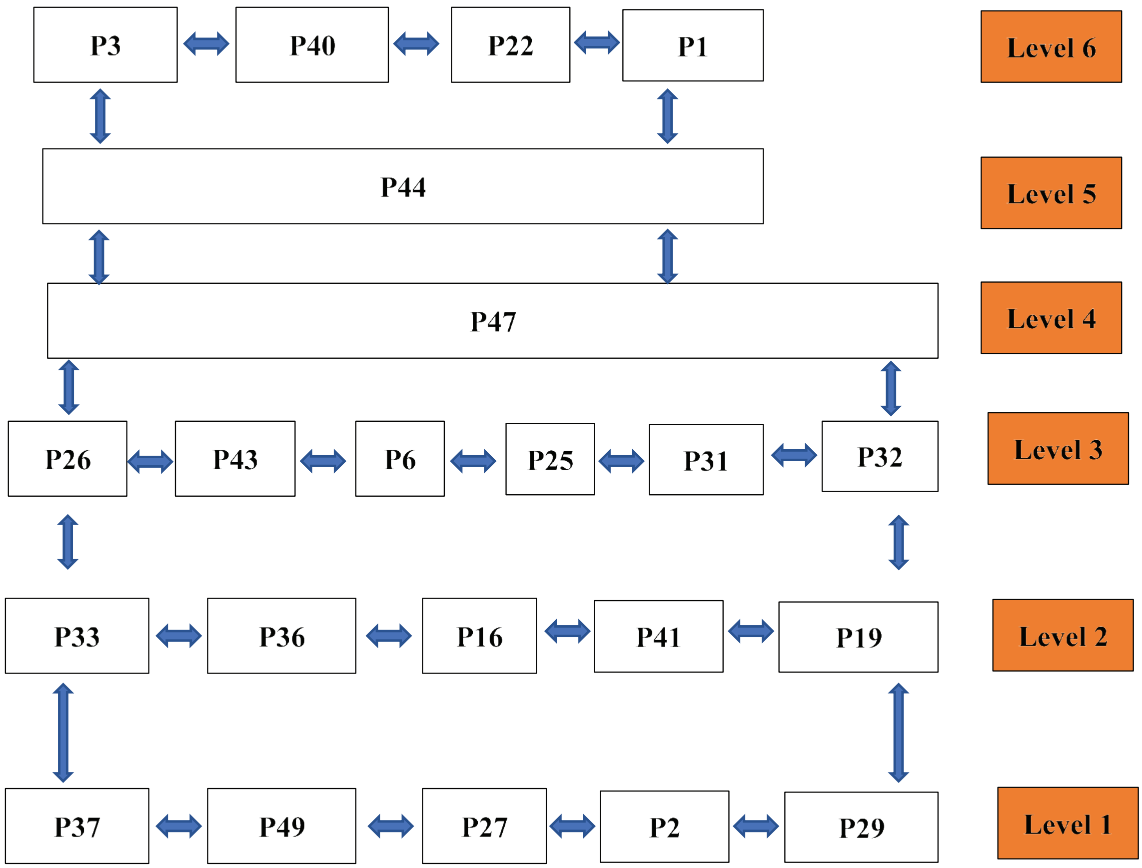

Fig. 1: Final ISM model of the productivity factors in the Jordanian construction projects post-COVID-19 pandemic. ISM, interpretive structural modelling.

with driving power under the y-axis and dependence power under the x-axis. The obtained results show that 17 factors are placed in cluster 1 which is called the 'autonomous factor'. The 'autonomous factors' include weak dependence and independence powers. The factors in this cluster may be strong but have few links so it is relatively disconnected from the system.

The second cluster is the 'dependent factors' which includes strong dependence powers factors and weak independence powers factors of productivity. It highlighted the significant dependent productivity factor in Jordanian construction projects where only one productivity factor, P29 placed in this cluster. The third cluster is the 'linkage factors', which include strong dependence and independence power factors of productivity which cause instability due to the results of any action on them affecting other factors and any feedback on themselves. The 'linkage factors' cluster does not have any productivity factor which means there are no critical factors affecting each other in a linkage relationship. The last cluster is 'Independence factors', which include a strong productivity factor and few weak productivity factors. Four productivity factors are located in this cluster P41, P6, P40 and P3.

5 Conclusions

This research provides critical productivity factors in the Jordanian construction projects post-COVID-19 pandemic. Fifty productivity factors were selected based on a critical literature review. A questionnaire was developed based on the outcomes of the literature review and then distributed across the Jordanian construction industry. The respondents, 267, were analysed to rank the main productivity factors. The obtained results determined 22 main factors which have a mean of 3.0 and above. The top five factors are Material shortage, Lack of empowerment (training/seminar), Late payment of salary, Poor communication & coordination and Improper planning & scheduling of work. These factors are quite similar to the main productivity factors pre-COVID-19 pandemic in Jordanian construction projects. Additionally, the COVID-19 pandemic has increased the number of critical factors

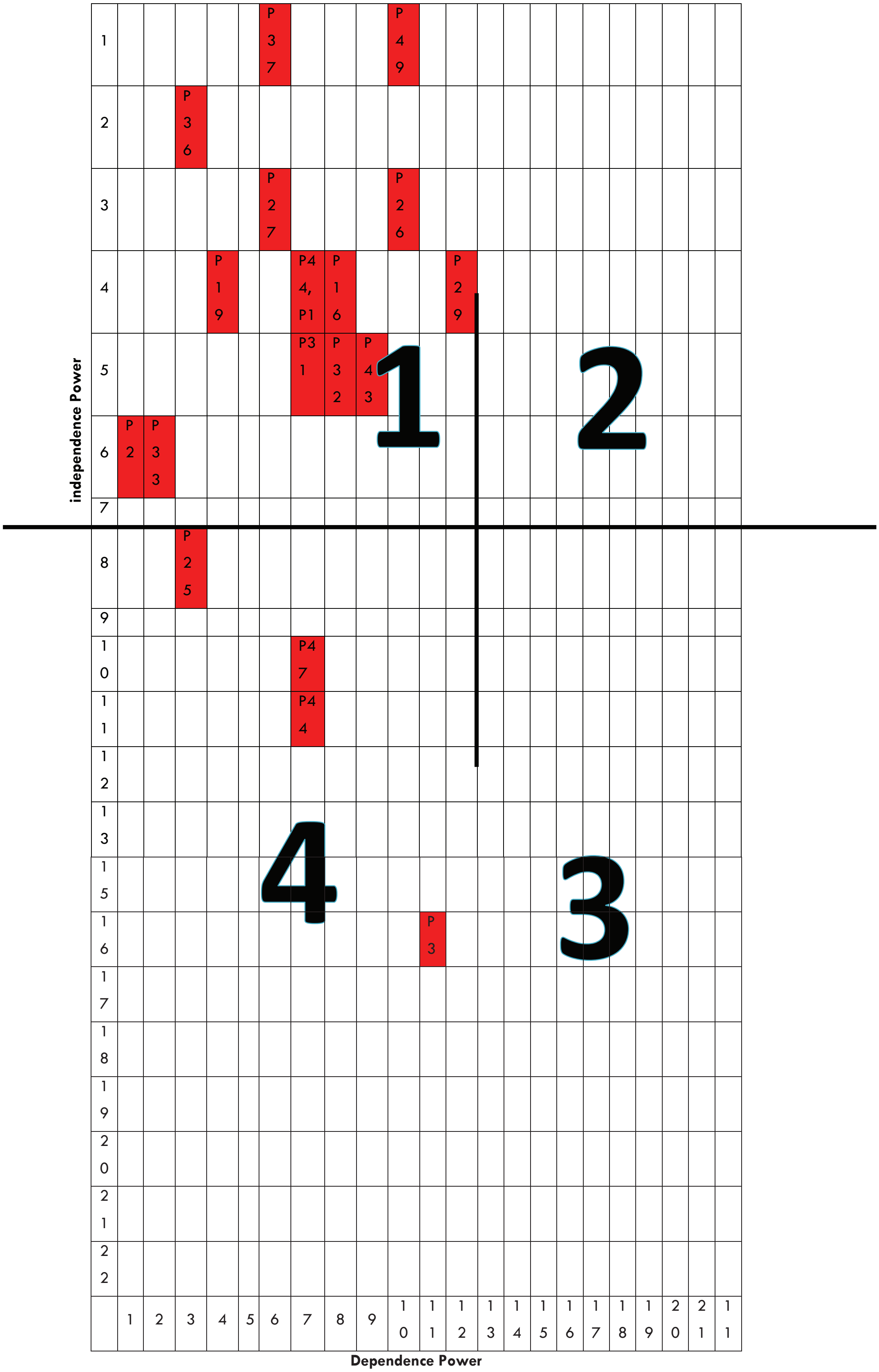

Fig. 2: MICMAC analysis of productivity factors in Jordanian construction projects.

that affect productivity in construction projects. A focus group consisting of selected experienced participants representing the construction sector conducted an ISM approach for a hierarchy of the productivity factors in construction projects. The ISM approach is an important technique for hierarchy ranking productivity factors and identifying the inter-relationship between these factors. This technique highlighted its efficiency in improving such types of topics by identifying the level of critical factors, barriers and processes and then paving the way for improving productivity in the construction sector by reducing the problems at each level. The ISM establishes a contextual association among six levels of productivity factors in Jordanian construction projects. Thus, to improve the productivity in construction projects, it is essential to alleviate challenges related to the factors in level 1 which are considered the weakest factors and so on. The obtained results distributed productivity factors over six levels. Level 6 contains the significant factors that have the greatest influence on productivity in construction projects. These factors are Lack of empowerment (training/seminar), Poor communication & coordination, Workers adhering to safety measures and infection control policy and Utilising traditional construction methods instead of modern technology. Level 1 included the factors that have the lowest influence on productivity in construction projects. MICMAC principle is used to ascertain the strength of each productivity factor. The factors are classified into four main groups, namely autonomous, dependent, linkage and independent, based on their driving power and dependent power. The results indicated that most productivity factors, 17 factors, were placed on the autonomous cluster which means that the 17 main factors may be strong but they are disconnected from the system. Additionally, the strong productivity factors do not affect each other as linkage factors and only four strong dependence factors are located in the 'Independence factors' cluster.

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