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Surman Journal for Science and Technology
ISSN: Online (2790-5721) - Print (2790-5713)
مجلة صرمان للعلوم والتقنية
Vol 6, No.2, Jun - Dec. 2024
Pages: 548 ~ 558

Applying Rasch Analysis Modeling to Assess the Reliability and Validity of Change Order Impacts (COI) on Performance of Libyan Construction Projects

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Abstract

Change order is a set of instructions that allow occurring modifications or changes on an earlier agreement, changes have become one of main and serious problems in construction projects, such changes may affect negatively on original scope, cost, and schedule of work or whole performance of the project. The current study is concerned with producing empirical evidence on the validity and reliability of the items that will be used in the questionnaire to evaluate the effects of changes on the performance of construction projects. In North West of Libya, 104 questionnaires were distributed between professional people from consulting firms, construction firms and government organization which associated to building construction projects. Analyzing was done by Rasch analysis Model via Mini steps software 5.8.0.0. The outcomes indicated that (PMC) PT-measure correlation value for 14 items range from 0.24 to 0.54 for the construct of change order impacts, except three items were -0.03, 0.01, and 0.09, which means below 0.19. In unidimensional measure, raw variance explained was 55.9% with the unexplained variance in the first factor was 7.8%. Meanwhile, the findings of the summary statistic indicate that item's reliability for constructs was 0.99. Otherwise, the items separation index of change order effect construct was (8.86). With exception to the three items (EQ_CP5, EQ_SP14, and EQ_SP13), The analytical discussion suggests that the 14 items on questionnaire effectively measure the concept of change orders impacts (COI). These analytical measures support the validation of the questionnaire's construct validity, making it suitable for further analysis within the conceptual framework. Such findings can be employed in future research to develop advanced models that provide in-depth explanations of these effects and their interrelationships, as well as their connections with other factors.

Keywords: *Building construction projects in Libya, Impacts of change orders (CO), Rasch measurement model, Validity, Reliability.*

1- Introduction:

Due to many challenges, the construction industry in Libya contributes less to the country's economy than other services industries [11]. Most of construction projects are continuously reported as facing poor performance [4]. One of the main issues faced by the construction projects in Libya is the problem of the change requests during the construction stage [22], a result of many causes such as changes in design, changes in plan and schedule, poor communication, financial difficulty, and a project complexity. Although, with the good and efficient planning of the projects, variation orders occurred [14]. Change orders in construction industry become a common phenomenon and unenviable [14]. According to Ghenbasha et,al[12] change order defined as the modifications of the design or alteration quality of works, as agreed upon the contract drawings, bill of quantities, and/or specifications. Change orders may take place in any construction project for many factors like as different site condition, changes or modifications in the scope of work, error in design, poor communication and coordination among parties of the project, conflicts in the contract, and changes

in design [3]. Change orders are the main cause why most construction projects don't meet up the specified time and cost as planned. In study conducted by Sheboob et al [22] confirmed that one of main factor of delay in construction projects in Libya was change orders. The amount of cost overruns 13 billion dollars per year in construction projects due to change orders in United States. Assaf and Al-Hejji [1] founded the main cause of time overrun in large construction projects in Saudi Arabia is change orders. By reviewing previous studies related to Libyan construction projects, the researcher found that there are many studies related to project delays and cost overruns, but there is a lake of studies on the subject of change orders and their effects. Therefore, the researcher took the opportunity to contribute to the topic of change orders through the study of a validly and reliability the items which used to measure the impact of change orders and their ability to do.

2- Previous studies

According to previous research, such as [5]; [2]; [6] ;[7] ;[10] ;[23]; [16]; [14]; [12]; [25], [20]; [18] mentioned negative effects of change orders on construction projects. The influence of occurrence of variation orders on the project performance is typically related to five categories, namely cost overrun, time overrun, degradation of quality, degradation of health and safety, and degradation of the professional relationships, Figure (1) and Table (1).Thus, the significance of the current study in order to examine the extent to which these elements are able to measure the impact of change orders on performance of Libyan construction projects.

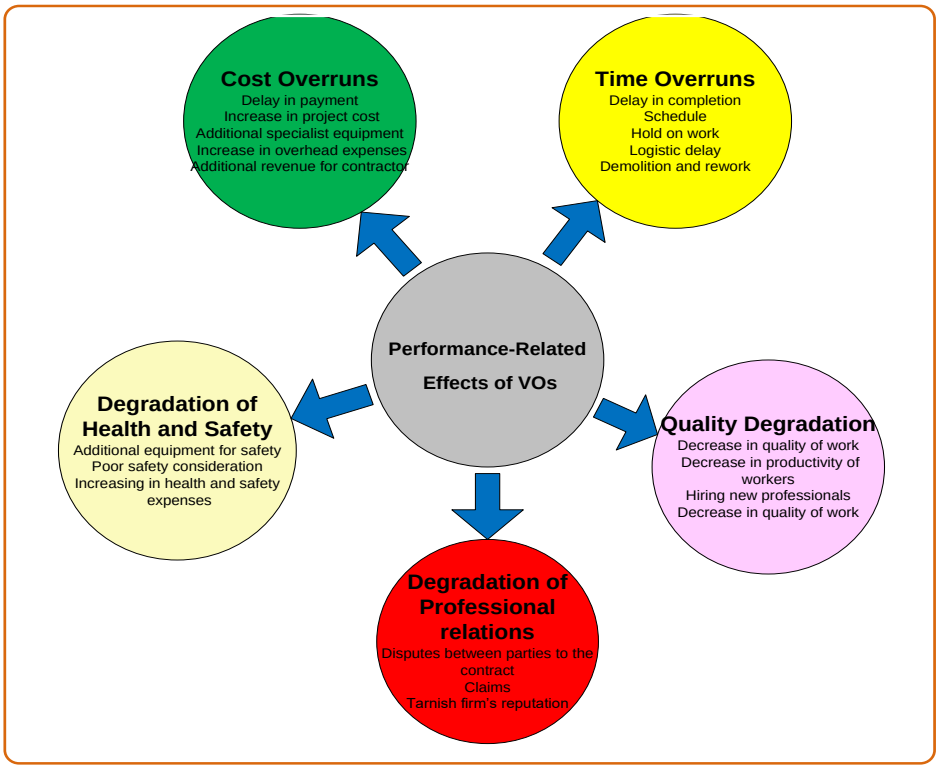

Figure (1) The influence of occurrence of variation orders

3- Objective of study

The current study is aimed to:

(1) Examine the validity of the Likert scale which employed to assessing the impacts of change order (ICO) in Libyan construction projects.

(2) Identify the validity and reliability of impacts of change order (ICO) in libyan construction projects via Rasch Measurement Model.

(3) Identify the adequacy of the separation index of impacts of change order (ICO) in libyan construction projects via Rasch Measurement Model.

(4) Identify the point measure correlation in the construct of the impacts of change order (ICO) scale which are in the acceptable range.

(5) Examine the ability of the participants on evaluating the questions (impacts of change order (ICO)) in Libyan construction projects via Rasch Measurement Model.

Table (1) the influence of change orders according previous research

CODE	ITMES OF CHANGE IMPACT	REFREANCES
TIME OVERRUN		
TP1	Delay in completion schedule	[23]; [3]; [14]
TP2	Hold on work	[15]; [3]
TP3	Logistic delay	[15]; [18]; [10]
TP4	Demolition and rework	[10]; [13]; [12]
COST OVERRUN		
CP5	Delay in payment	[15]; [3]; [5]
CP6	Increase in project cost	[3]; [14]; [12]
CP7	Additional specialist equipment	[3]; [12]; [15]; [6]
CP8	Increase in overhead expenses	[25]
CP9	Additional revenue for contractor	[5]
QUALITY DEGRADATION		
QP10	Decrease in quality of work	[24]; [3]; [5]; [15]
QP11	Decrease in productivity of workers	[5]; [3]; [15]
QP12	Hiring new professionals	[5]
SAFETY DEGRADATION		
SP13	Degradation of health & safety	[20]; [10]; [15]
SP14	Poor safety conditions	
DEGRADATION OF PROFESSIONAL RELATIONS		
PRP15	Disputes between parties to the contract	
PRP16	Poor professional relations	[5]; [25]
PRP17	Tarnish firm’s reputation	[3];[25];[15]

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4- Methodology:

Rasch analysis is a sophisticated statistical mathematical modeling method used to evaluate the psychometric properties of measurement instruments, such as questionnaires. It's based on the concept of a "latent trait," which is an underlying characteristic or ability that the questionnaire aims to measure (Bond & Fox, 2007). In this research, Rasch analysis is employed to attest construct validity of impacts of change orders (ICO) via using Ministeps software 5.8.0.0. The impacts of (CO) questionnaire involved 17 items, labelling with five Likert scale.

5- Data analysis:

5-1 Validity of Likert Scale for Structure Change Order Impacts (COI)

Table 2 presented the effectiveness of the 5-point Likert scale was evaluated using criteria outlined by Linacre (2006). This likely involves assessing the distribution of responses across the five categories to ensure they are adequately utilized and provide meaningful information. According to obtained result, the five Likert scale for structure of impacts of change orders (ICO) questionnaire exceeded the suggested minimum number of responses of 20 (163, 275, 342, 562, and 426).

Table (2) Validity of Likert Structure of Change Order Impacts (COI)

SUMMARY OF CATEGORY STRUCTURE. Model="R"

CATEGORY LABEL	SCORE	OBSERVED COUNT	%	OBSVD AVRGE	SAMPLE EXPECT	INFIT MNSQ	OUTFIT MNSQ	STRUCTURE CALIBRATN	CATEGORY MEASURE	
1	1	163	9	-.92	-.90	.97	1.08	NONE	(-2.63)	1
2	2	275	16	-.59	-.57	.91	1.03	-1.27	-1.13	2
3	3	342	19	.12	.10	.99	.96	-.48	-.10	3
4	4	562	32	1.06	1.04	.89	.91	.08	1.07	4
5	5	426	24	1.67	1.69	1.14	1.07	1.67	(2.91)	5

OBSERVED AVERAGE is mean of measures in category. It is not a parameter estimate.

Furthermore, the threshold calibrations (-1.27, -0.48, 0.08, and 1.67) for CO impacts questionnaire increased monotonically with Likert structure label, representing that the response of five Likert categories was used from examinees in an intended manner.

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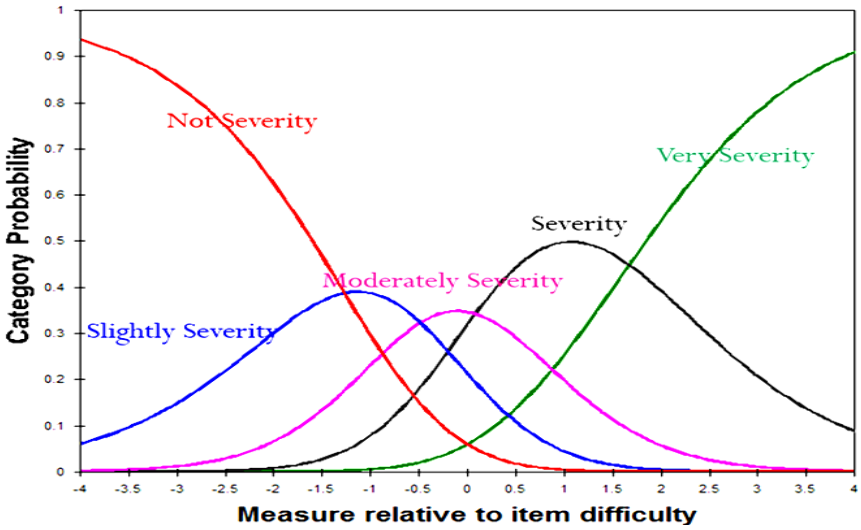

Figure 2 Modal Probability Curve of Change Order Impacts (COI)

Both the category measures (-2.63, -1.13, -.10, 1.07, and 2.91) and average measures (-.92, -.59, .12, 1.06, and 1.67) of items of impacts of change orders questionnaire were found to exhibit a monotonic trend. This suggests that the responses generally increased or decreased in a consistent manner across the categories.

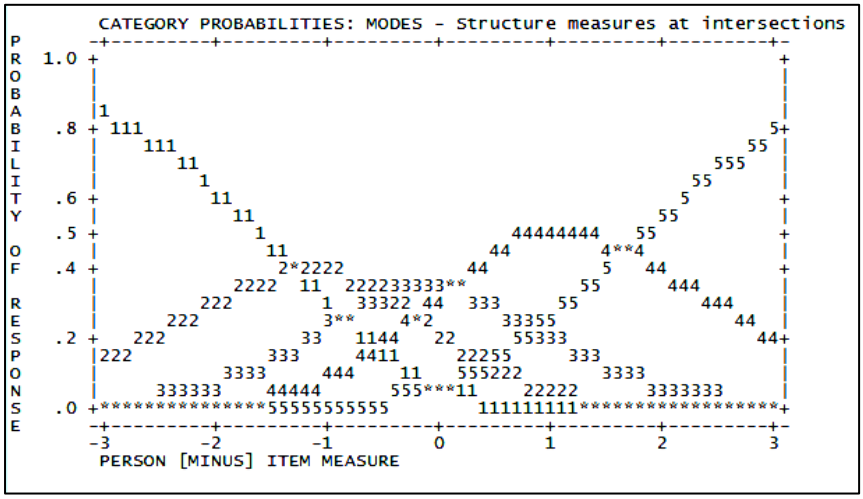

Figure 3 Category Probability Curve of CO impacts

Furthermore, both the modal probability curves (Figure 1.1) and category probabilities (Figure 1.2) for the impact questionnaire showed distinct peaks for each category, indicating that the responses were not uniformly distributed and that the five-point Likert scale was effectively utilized.

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5-2 Item Fit MNSQ Estimations for Structure (CO) impacts

An analysis of the (PT-MEASURE CORR) values presented in Table 3 demonstrates that the majority of items exhibit a moderate, positive correlation with the concept of impacts of change orders. The observed correlations ranged from 0.03 for item EQ-CP5 to 0.54 for item EQ-QP12.

Table (3) Item Fit MNSQ Estimations of

ITEM STATISTICS: CORRELATION ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	ITEM
5	248	104	1.31	.10	.92	-.6	.95	-.4	.03	.35	34.6	36.3	EQ_CP5
14	383	104	-.08	.11	.86	-1.0	.88	-.8	.01	.31	43.3	43.5	EQ_SP14
13	380	104	-.04	.11	.82	-1.3	.82	-1.4	.09	.31	49.0	42.6	EQ_SP13
1	451	104	-1.12	.14	1.11	.8	1.11	.7	.21	.24	41.3	47.5	EQ_TP1
8	446	104	-1.02	.14	.97	-.1	1.16	1.0	.21	.25	51.0	47.6	EQ_CP8
6	474	104	-1.67	.17	1.43	2.4	1.47	2.6	.22	.21	63.5	58.0	EQ_CP6
15	467	104	-1.48	.16	.92	-.5	.93	-.4	.25	.22	53.8	54.0	EQ_PRP15
16	459	104	-1.29	.15	.90	-.6	.92	-.4	.26	.23	51.9	49.8	EQ_PRP16
2	415	104	-.50	.12	.92	-.5	.93	-.4	.29	.28	51.0	48.1	EQ_TP2
17	309	104	.71	.10	1.39	3.0	1.38	2.9	.30	.35	27.9	34.6	EQ_PRP17
9	452	104	-1.14	.14	1.01	.1	.97	-.1	.35	.24	53.8	48.7	EQ_CP9
3	411	104	-.44	.12	.68	-2.4	.67	-2.5	.38	.29	57.7	48.0	EQ_TP3
4	227	104	1.53	.10	1.00	.0	1.00	.1	.38	.34	30.8	37.0	EQ_TP4
7	295	104	.85	.10	.82	-1.6	.82	-1.6	.40	.35	37.5	34.6	EQ_CP7
11	235	104	1.44	.10	1.06	.5	1.06	.5	.52	.35	38.5	36.6	EQ_QP11
10	244	104	1.35	.10	1.15	1.3	1.17	1.4	.54	.35	38.5	36.5	EQ_QP10
12	221	104	1.60	.11	.89	-.9	.89	-.8	.54	.34	36.5	37.0	EQ_QP12
MEAN	359.8	104.0	.00	.12	.99	-.1	1.01	.0			44.7	43.6	
S.D.	94.1	.0	1.15	.02	.19	1.3	.20	1.4			9.8	7.1	

In essence, the findings suggest that most of the questionnaire items are adequately related to the concept of impacts variation orders, the magnitude of correlation located equally and above the suggested criteria 0.20. While three specific items (EQ-SP13, EQ-CP5 and EQ-SP14), may require further investigation or revision. Although these items are theoretically related to the impacts of change orders, and the remaining Rasch analysis criteria are met, the appropriate decision in such a case would be to avoid using them in future research.

The majority of questionnaire items (14 out of the total) demonstrated a moderate, positive correlation with the point measure, indicating a consistent and positive relationship with the overall concept of 'impacts change order' (ICO). This suggests that these items are systematically measuring the same latent construct related to the impacts of change orders.

As shown in Table 3 the infit MNSQ values for the all 14 items of the impacts of change orders (ICO) questionnaire, which were well located within acceptable values >0.6 and < 1.4 , showing that the 14 items acceptable fit to the Rasch model. By another words, 14 items included in the questionnaire effectively contribute to measuring the construct of change order impacts (COI). This suggests that the data collected accurately reflects the underlying concept of change order impacts, as evidenced by the results of the Rasch analysis.

5-3 Rasch Principal Components Analysis (RPCA) for Structure (CO) Impacts

As appeared on the result of Table 4, the Rasch–residual percentage based principal components analysis (RPCA) for structure (CO) impacts, suggested that around 55.9% from the examinees was

accounted by the modeled data. In addition, 55.9% of the concept of change orders impacts (COI) was explored by using 14 items.

Table (4) RPCA for structure of change orders impacts (COI)

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)					
		-- Empirical --			Modeled
Total raw variance in observations	=	39.1	100.0%		100.0%
Raw variance explained by measures	=	22.1	56.5%		55.9%
Raw variance explained by persons	=	2.7	7.0%		6.9%
Raw Variance explained by items	=	19.3	49.5%		49.0%
Raw unexplained variance (total)	=	17.0	43.5%	100.0%	44.1%
Unexplned variance in 1st contrast	=	3.2	8.2%	18.8%	
Unexplned variance in 2nd contrast	=	1.9	4.8%	11.0%	
Unexplned variance in 3rd contrast	=	1.5	3.8%	8.8%	
Unexplned variance in 4th contrast	=	1.4	3.7%	8.5%	
Unexplned variance in 5th contrast	=	1.3	3.4%	7.8%	

The magnitude of the unidimensionality index exceeded the threshold of 50% as recommended by Mofreh et al. (2014). This result suggests that the items used to measure the construct of impacts of change orders (ICO) effectively assess a single underlying construct, indicating unidimensionality. In other words, the items do not appear to measure multiple, distinct dimensions of change order impacts. This analysis confirms that the 14 items included in the change order impact questionnaire function effectively within a single dimension and are suitable for assessing the overall impact of change orders (COI).

5-4 Separation and Reliability of Change Orders Impacts (CIO)

As shown in table 5, the reliability of items of change orders impacts was more than high, around (0.99) closing to 1.

Table (5) Separation and Reliability of Change Orders Impacts (CIO)

SUMMARY OF 17 MEASURED ITEM

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	359.8	104.0	.00	.12	.99	-.1	1.01	.0
S.D.	94.1	.0	1.15	.02	.19	1.3	.20	1.4
MAX.	474.0	104.0	1.60	.17	1.43	3.0	1.47	2.9
MIN.	221.0	104.0	-1.67	.10	.68	-2.4	.67	-2.5
REAL RMSE	.13	TRUE SD	1.14	SEPARATION	8.86	ITEM	RELIABILITY	.99
MODEL RMSE	.12	TRUE SD	1.14	SEPARATION	9.20	ITEM	RELIABILITY	.99
S.E. OF ITEM MEAN = .29								

The ratio above suggested that the ordering of the 14 items of change orders impacts was highly replicable with a similar population. The item separation index of items of change orders impacts is 8 (8.86). Such found result showed that items of change orders impacts are scattering widely and ideally in relation to the assessed concept of impact of change orders (COI), such result recommended by (Smith Jr, 2001).

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5-5 Wright Map of Change Order Impacts (COI)

Persons in Rasch model is a term used for referring for participants. As shown in Figure 5, the item-person map for (COI) change orders impact, the examinees who are likely to be in high ability to answer the questions associated to (COI) which located at the top of the map. Meanwhile, the examinees with less ability to answer the questions associated to (COI) are located at the bottom of the map. The right side of the map visualized the distribution of items of (COI) term of the relative frequency of ability and endorsement. The left side of the map pictured the distribution of persons, with each parcel "#" representing 5 participants.

As shown in Figure 4, in the map, the normal distributions of items of change order impacts (COI) are symmetrically visualized within the acceptable standard for the mentioned T-Statistics (2, -2). Similarly, the normal distributions of persons who are examinees were located within the acceptable standard for the mentioned T-statistics (+2, -2). which means that normal distributions of Items of change orders impacts (COI) are symmetrically located across the majority of examinees or participants distributions. It is clear that 14 items have the ability to evaluate strongly the concept of change orders impacts (COI). Such analytic measures supported the verification of construct validity of change order impacts (COI).

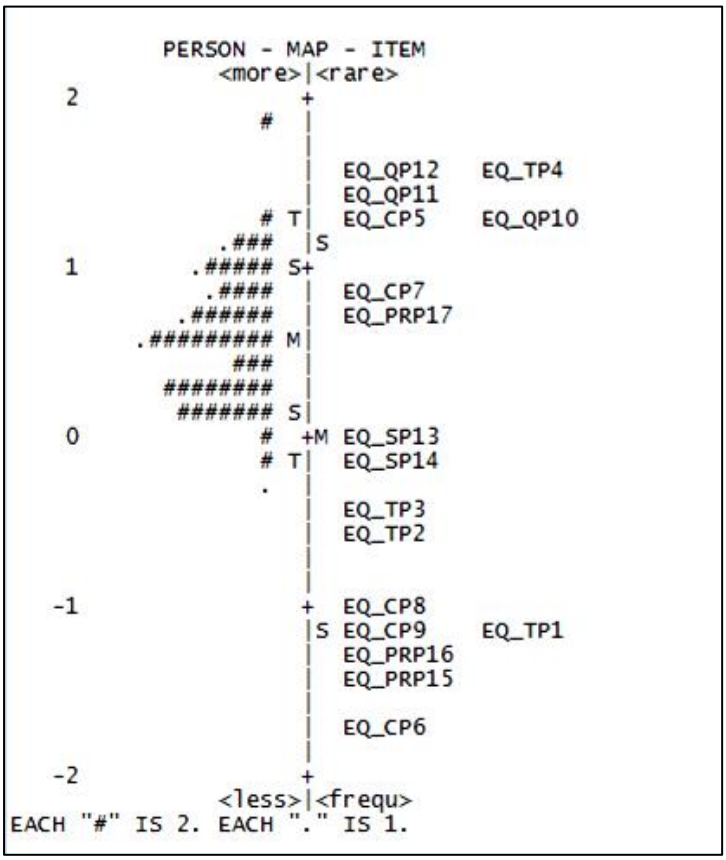

Figure 4 Wright Map of Change Order Impacts (COI)

6 Conclusion

This study aims to evaluate the accuracy and consistency of the impacts of change orders on performance of building construction projects during construction phase using the Rasch Measurement Model. The results of the Rasch analysis confirm that the study's objectives were achieved. The items demonstrated high reliability, indicating their stability. The separation index values exceeded 2 for the difficulty level, which is considered acceptable. The separation index also revealed that the constructs ranged from 8 to 9, surpassing the acceptable value of 2. With exception to the three items (EQ_CP5, EQ_SP14, and EQ_SP13), The analytical discussion suggests that the 14 items on questionnaire effectively measure the concept of change orders impacts (COI). These analytical measures support the validation of the questionnaire's construct validity, making it suitable for further analysis within the conceptual framework. Such findings can be employed in future research to develop advanced models that provide in-depth explanations of these effects and their interrelationships, as well as their connections with other factors. Such insights can contribute to effective strategies for mitigating negative impacts on construction project performance.

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