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Designing a Structural Model for Managing Production Contract Risks: A Path Towards Global Sustainability

Mohammad Foronzadeh* • Zahra Saadi

Department of Management and Industrial Engineering,
Malek Ashtar University, Tehran, Iran

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Abstract: The objective of this study is to identify and mitigate production contract risks within construction industry organizations Towards Global Sustainability. In this topic, several key theories, models, and frameworks provide a solid basis for understanding the investigation. Here are some relevant concepts: Risk Management Theory, Contract Theory, Systems Theory, Sustainable Development Theory, Stakeholder Theory, Supply Chain Management Framework, and Integrated Risk Management Framework. These theories and frameworks form a comprehensive theoretical foundation for investigating the management of production contract risks, emphasizing the importance of sustainability.

A combined quantitative and qualitative methodology was employed to provide a comprehensive and detailed analysis of the various dimensions of this issue. Initially, a thorough review of existing literature and expert opinions was conducted to identify prevalent risks within construction production contracts. The DEMATEL technique was utilized to analyse the interrelationships and influence among these identified risks. The results identified five major risks, ranked in order of significance: fluctuations in demand, delays, substandard quality and non-compliance in construction, unauthorized disclosure of project information, and incompatibility of components with the overall system. By prioritizing these risks, construction organizations can effectively prevent the occurrence of adverse events.

Keywords: **Production contracts, construction industry, risk components, sustainability.**

*Corresponding author.
E-mail address: mohforouzandeh@gmail.com (M. Foronzadeh).
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1. Introduction

Today, an adaptive dynamic risk management model can be developed, focusing on transforming uncertainty into certainty through risk management tools. This model emphasizes the importance of integrating risk management into the management structure to enhance sustainability and efficiency (Тернющенко et al., 2022).

The literature on risk management in construction contracts highlights several gaps. One significant gap is the lack of comprehensive frameworks that address the equity gap (EG) in construction contracting, which includes elements like information asymmetry, risk allocation, and power imbalances between contracting parties (Zhu & Cheung, 2022). Additionally, there is a need for more in-depth studies on the risks associated with outcome-based contracts (OBCs) from a provider's perspective, particularly concerning commercial and operational risks (Hou & Neely, 2018).

Furthermore, existing risk identification methods heavily rely on manual reviews, which are inefficient and limited by personnel experience, indicating a need for more intelligent, automated approaches (Zhou et al., 2025). Risk management is crucial in the construction industry due to its significant impact on project performance, including cost, time, and quality (Raj & Wadsamudrakar, 2018). Effective risk management can prevent unwanted consequences and improve project outcomes by ensuring better communication and risk-sharing among project actors (Lambert, R. A. 2001).

The absence of systematic risk management, especially in the program phase, is a noted weakness that needs addressing to deliver projects with certainty (Raj & Wadsamudrakar, 2018). Additionally, risk management practices are essential for strategic decision-making and feasibility studies, as they help in evaluating and mitigating potential risks (Ijigah et al., 2013).

2. Theoretical Framework

There are several interrelated theories and models that provide a comprehensive understanding of the context and objectives of the research. Below are the key components of this framework:

1. Risk Management Theory: Identification, assessment, mitigation, and monitoring of risks.
Application: To establish the foundation for developing a structural model that effectively addresses and manages production contract risks.

2. Contract Theory: Incentives, contractual arrangements, and the behavior of parties involved in contracts.
Application: To offer insights into how contracts can be structured to minimize risks and enhance performance, particularly in production contexts.

3. Systems Theory: Understanding organizations as interconnected systems with various components.
Application: To aid in analyzing how different elements of production contracts interact and impact overall risk management strategies.

4. Sustainable Development Theory: Balancing economic growth, environmental protection, and social equity.
Application: To align the research with global sustainability goals and the SDGs, emphasizing the need for sustainable practices in production.

5. Stakeholder Theory: The importance of considering the interests and influences of all stakeholders in decision-making processes.
Application: To highlight the necessity of engaging various stakeholders in the development and implementation of risk management strategies.

6. Supply Chain Management (SCM) Framework: Integration and collaboration across the supply chain to optimize performance and reduce risks.
Application: To provide a context for understanding how production contracts fit within the broader supply chain and how risks can be managed collaboratively.

7. Integrated Risk Management (IRM) Framework: A holistic approach to managing risks across an organization.
Application: To facilitate the development of a comprehensive model that incorporates various risk management practices relevant to production contracts.

This theoretical framework serves as a guiding structure for the research, integrating essential theories and models that inform the design of a structural model for managing production contract risks. It emphasizes the importance of sustainability and the advancement of the SDGs, ensuring that the proposed model is both practical and aligned with global objectives (Uhlmann, I. R., et al, 2018).

This study aims to develop a structural model for identifying and evaluating risks associated with production contracts in the construction industry. The model uses a combination of quantitative and qualitative methods

to provide a comprehensive analysis of the relevant dimensions. The results of this study can be directly used by organizations.

The construction industry is a complex and high-risk sector. Production contracts in this industry are often plagued by numerous risks, including time delays, cost overruns, and quality defects (Auriol, E., & Picard, P. M. 2013). To manage these risks, it is essential to develop a structural model for identifying and evaluating risks associated with production contracts. This study uses a combination of quantitative and qualitative methods to provide a comprehensive analysis of the relevant dimensions.

From a philosophical perspective, this study is considered applied research, as its results can be directly used by organizations. In terms of data collection, this study is descriptive-survey research study. A systematic method was used to identify and extract the factors influencing the risk components of production contracts.

For this purpose, credible scientific articles available in databases such as Google Scholar, Emerald Insight, and ScienceDirect were reviewed and analyzed. From the articles, 23 risk factors in production contracts were extracted. Then, these factors were weighted using expert opinions. In other words, with the help of expert opinions, the identified factors were localized and weighted using the Likert scale. Experts confirmed 17 of the identified factors.

In the next step, a questionnaire was used to ask experts in the production industry about the importance of the 17 influential factors that had been weighted by experts. The prepared questionnaire was evaluated using Cronbach's alpha, and its value was 0.934. This Cronbach's alpha value is greater than the reference value of 0.7, indicating that the questionnaire has high reliability. For the reliability of the questionnaire, industry experts were also used, which further supports the reliability of the questionnaire.

To evaluate the effectiveness of the extracted risk components from the literature review, a questionnaire was used with the Delphi method, which was given to industry experts, and 17 components were extracted, which are shown in the Table 1.

Designing a structural model of risks in production contracts within the construction industry involves several methodologies and frameworks. One approach is the use of a combined Fuzzy Failure Mode and Effect Analysis (FMEA) and Fuzzy Analytical Hierarchy Process (AHP), which helps in identifying failure modes, assessing their

Table 1. Identified risks for production contracts based on literature review and expert judgment.

Resources	Components	Row
(Sheikhi Mehrabadi & Bagheri Todashki, 2021)	Number of credits and facilities received	Q1
(Kazaroni et al., 2013)	The amount of currency fluctuations	Q2
(Karimmian et al., 2017).	Delays in the supply of materials and parts	Q3
(Ijigah et al., 2013).	The rate of change in demand	Q4
(Shirijiyan et al., 2021).	The level of unsatisfactory quality and non-conformities in production	Q5
(Bent Al-Hoda, 2015).	Percentage of technological changes and innovations in production	Q6
(Uhlmann, I. R., et al, 2018).	Dangers from devices if not repaired and calibrated	Q7
(Mazaheri et al., 2017).	The extent of non-compliance with production standards	Q8
Badini, H. (2012).	Violation of intellectual property laws	Q9
(Mokhtari, H., & Bidabadi, H.S. 2021).	Disruption in the production system and industrial sabotage	Q10
(Ijigah et al., 2013).	Disclosure of production information	Q11
(Johan, S., & Ariawan, A. 2021).	Unsuccessful transfer of product production line after the end of the specified period	Q12
(Khan, A. W., & Khan, S. U. 2012).	Non-compliance of the beneficiaries with the provisions of the contract	Q13
(Rezaeian et al., 2018).	The degree of industry dependence on knowledge-based companies collaborating in production	Q14
(Rezaeian et al., 2018).	Inability to attract the capital needed for production	Q15
(Kim et al., 2006).	Lack of allocation and compatibility of the component product with the supplier's macro product	Q16
(Rezaeian et al., 2018).	The degree of industry dependence on knowledge-based companies collaborating in production	Q17

impact, and planning corrective actions. This method addresses the limitations of traditional FMEA by using fuzzy logic to map relationships between impact, probability, and detection/control, thus determining the criticality of risk events (Abdelgawad & Fayek, 2010).

Another approach is the development of a Risk Management Index (RMI), which evaluates risk management practices and establishes a risk rating tool. This model helps in strategic decision-making and feasibility studies for construction projects (Ijigah et al., 2013).

The DEMATEL method is a multi-attribute decision-making method (MADM) that expresses the influence and impact of criteria on each other and determines the relationships between criteria. This technique was presented by Fontella and Gabos in 1971. The important point is that this technique does not provide a ranking or prioritization of criteria and only examines the criteria in terms of cause and effect.

3. Methodology

Analysis and assessment are fundamental components of the scientific method, serving as the basis for any research approach. Broadly speaking, analysis refers to the process that guides the entire research journey from problem selection to reaching a conclusion. In this study, for data analysis, we will employ a multi-criteria decision-making technique known as the DEMATEL method. Below, we will provide a brief overview of this method.

DEMATEL is a multi-attribute decision-making method used to identify the pattern of causal relationships between the variables under study. This method is used to identify the pattern of relationships between a set of indicators. The term DEMATEL stands for Decision Making Trial and Evaluation. This method was presented by Fonetla and Gabus in 1971.

This technique is based on diagrams, which, by utilizing the opinions of experts in identifying the factors in a system and by applying the principles of graph theory, extracts the influential or influenced relationships of the elements and presents a hierarchical and systematic structure from them, in a way that determines the intensity of the effect of the aforementioned relationships in the form of a numerical score.

This technique does not give us a ranking of alternatives; rather, it is used to determine the degree of effectiveness of the criteria in a system. The steps for implementing the DEMATEL technique are shown in Figure 1.

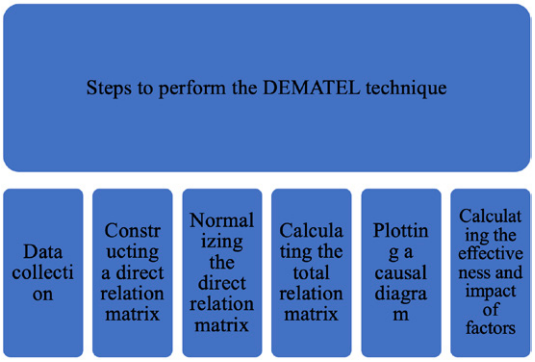


Figure 1. Steps to perform the DEMATEL technique.

$$Z = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_3 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_3 \end{array} \\ \begin{bmatrix} 0 & a_{12} & \dots & a_{1n} \\ a_{21} & 0 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 0 \end{bmatrix} \end{array}$$

Figure 2: Pairwise comparison matrix.

Step 1: Identification of the factors involved in the problem.
Using the Delphi method, a list of the existing and influential factors in the problem is extracted based on the opinions of the organization's expert group, and these factors are placed at the vertices of a digraph.

Step 2: Determination of the governing relationships between factors through pairwise comparison.
Using the experts' opinions, the governing relationships between the vertices are determined, and an *n.n* pairwise comparison matrix of the factors (Fig 2), which represents the degree of influence of the relationships between them, is constructed according to each expert's perspective (Table 2).

Table 2. Converting qualitative to quantitative impact.

Verbal phrase	Corresponding number
No impact	1
Very little impact	3
Little impact	5
High impact	7
Very high impact	9

Step 3: Calculating the direct matrix using group pairwise comparisons.
The matrices obtained in the previous step are examined, and the existence or non-existence of a final relationship between two factors is determined by the majority vote of decision-making experts. The direct relationship matrix M is then formed. This is done by assigning a value of zero to the corresponding entry in matrix M if more than half of the experts confirm the intensity of the effect of factors A and B. Otherwise, the relevant score is determined based on the collective agreement of experts or using the simple average of opinions and placed in the corresponding entry.

Step 4: Drawing the direct relationship diagram.
Draw the diagram corresponding to the direct relationship matrix M, such that:

- The vertices represent the factors.
- The arcs represent the direct relationships between each pair of factors.
- The weight of each edge represents the score given to each direct relationship.

Step 5: Normalizing matrix M.
Calculate the row sum of the entries in matrix M and multiply the inverse of the maximum value by the entries in matrix M according to Equation 1. This determines the relative intensity governing the direct relationships.

$$N=K.M \tag{1}$$

Step 6: Calculating of the total relations matrix.
In this step, the total relations matrix, representing the relative intensity of both direct and indirect relationships, is constructed based on Equation 2.

$$T=N(1-N)-1 \tag{2}$$

Step 7: Drawing the causal diagram.
In this step, the sum of the row and column elements of the total relations matrix (T) is calculated and analyzed as follows:

- The sum of the elements in each row (R) for a factor indicates the extent to which that factor influences other factors within the system (degree of influence). Higher values of this variable signify a greater impact of the factor.
- The sum of the elements in each column (J) for a factor indicates the extent to which that factor is influenced by other factors in the system (degree of being influenced).
- Accordingly, the horizontal vector (R + J) represents the overall interaction of the factor within the system. In other words, the greater the value of (R + J), the more interaction the factor has with other factors in the system.
- The vertical vector (R - J) reflects the degree of influence of each factor. Specifically, if (R - J) is positive, the factor is categorized as a cause, and if negative, it is categorized as an effect.

Finally, a Cartesian coordinate system is constructed. In this system, the horizontal axis represents the values of (R + J), and the vertical axis represents (R - J). The position of each factor is determined by a point with coordinates (R + J), (R - J) in the system. As a result, a graphical diagram is also obtained.

4. Results and Discussions

An (N.N) matrix is initially constructed, referred to as the direct-relation matrix, to identify the interrelationships among (N) criteria, and denoted by (X). Experts are then asked to evaluate the degree of influence exerted by each criterion on the others, using a numerical scale ranging. When multiple expert opinions are taken into account, the simple average of their evaluations is calculated, and the matrix (X) is subsequently formulated.

The normalization of the direct-relation matrix is performed using the formula (N = X / K), as shown in Equation (2). To calculate (K), the sums of all rows and columns of the matrix are first computed. The largest resulting value is identified and denoted as (K). Subsequently, all elements of the direct-relation matrix are divided by (K) to obtain the normalized matrix (Table 3).

The total relationship matrix is calculated through the following steps. First, an identity matrix is constructed. The identity matrix is subtracted from the normalized matrix and the resulting matrix is inverted. Finally, the inverse matrix (matrix multiplication) is multiplied by the normalized matrix to obtain the total relationship matrix. Other steps be done in Table 4 to 8.

Table 3. Normalization of the direct-relation matrix.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	SUM
Q1	0	3.8	4.6	5	5.8	6.2	6.2	6.6	5	5.4	5.4	5.8	5	5	4.6	5.8	5.4	85.6
Q2	4.2	0	5.4	5.4	5.8	6.6	5	5.8	5.4	4.6	4.6	5.4	5.8	6.2	5.4	7	6.2	88.8
Q3	3.8	3.8	0	5.4	4.6	5	5.8	5.4	3.8	4.2	5	4.6	4.2	5	5.4	6.6	6.2	78.8
Q4	5.8	5.4	7.4	0	3.8	4.6	7.8	5.8	5.8	6.2	6.2	5.4	5	3.4	5.4	7	5	90
Q5	5.8	3.8	5.8	5.4	0	6.4	5	5	5.8	5.8	5.8	5.8	5.8	5	5.4	4.6	4.6	85.8
Q6	5	3.8	5.4	6.2	4.6	0	6.2	5.4	5.4	5.8	5.8	5.4	4.6	4.6	5.8	5	5.4	84.4
Q7	4.6	5	4.2	5.4	5.4	6.2	0	4.6	6.6	5	5	5.8	5.8	6.6	6.2	6.2	5.4	88
Q8	4.2	3.4	6.2	5	6.2	5.4	5.8	0	4.6	4.2	4.6	5.4	5.8	4.6	4.2	5.4	6.2	81.2
Q9	6.2	3.4	7.4	4.6	5.8	5.4	5.8	6.6	0	5	5.8	4.2	4.6	5.4	3.8	5.4	5.8	85.2
Q10	5.8	5.4	4.6	4.2	4.6	4.6	5.4	5.8	5	0	5.8	5.4	5.4	5.4	5.4	4.2	5.4	82.4
Q11	4.6	5.8	4.2	3.8	5.8	5.4	6.6	5.8	6.6	3.8	0	6.6	5	5	5	5.8	5.8	85.6
Q12	3.8	4.6	4.6	4.6	5.4	4.2	7	4.6	7	5.4	6.6	0	5.4	6.6	6.2	6.2	6.2	88.4
Q13	5	3.8	4.9	4.2	4.6	4.2	5	5.4	5.4	6.2	4.6	5.8	0	4.6	5.4	5.8	5.8	80.7
Q14	5.8	4.6	6.6	4.2	6.4	3.8	5.8	5.4	4.6	6.2	4.6	5.4	5	0	3.8	4.6	3.6	80.4
Q15	5	5	6.2	4.6	4.6	7	5.4	6.6	6.2	4.6	4.2	5	4.6	5.4	0	6.2	6.6	87.2
Q16	4.2	5.8	6.2	5	6.2	5.4	5.4	4.6	6.6	5	5.4	4.2	4.2	5	5.4	0	2	80.6
Q17	5	3.8	5.4	4.6	6.2	5	6.2	5	5.4	5	6.6	5	6.2	5.4	5	7.4	1	88.2

Table 4. Calculation of the full correlation matrix.

N	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
Q1	0.00000	0.04222	0.05111	0.05556	0.06444	0.06889	0.06889	0.07333	0.05556	0.06000	0.06000	0.06444	0.05556	0.05556	0.05111	0.06444	0.06000
Q2	0.04667	0.00000	0.06000	0.06000	0.06444	0.07333	0.05556	0.06444	0.06000	0.05111	0.05111	0.06000	0.06444	0.06889	0.06000	0.07778	0.06889
Q3	0.04222	0.04222	0.00000	0.06000	0.05111	0.05556	0.06444	0.06000	0.04222	0.04667	0.05556	0.05111	0.04667	0.05556	0.06000	0.07333	0.06889
Q4	0.06444	0.06000	0.08222	0.00000	0.04222	0.05111	0.08667	0.06444	0.06444	0.06889	0.06889	0.06000	0.05556	0.03778	0.06000	0.07778	0.05556
Q5	0.06444	0.04222	0.06444	0.06000	0.00000	0.07111	0.05556	0.05556	0.06444	0.06444	0.06444	0.06444	0.06444	0.05556	0.06000	0.05111	0.05111
Q6	0.05556	0.04222	0.06000	0.06889	0.05111	0.00000	0.06889	0.06000	0.06000	0.06444	0.06444	0.06000	0.05111	0.05111	0.06444	0.05556	0.06000
Q7	0.05111	0.05556	0.04667	0.06000	0.06000	0.06889	0.00000	0.05111	0.07333	0.05556	0.05556	0.06444	0.06444	0.07333	0.06889	0.06889	0.06000
Q8	0.04667	0.03778	0.06889	0.05556	0.06889	0.06000	0.06444	0.00000	0.05111	0.04667	0.05111	0.06000	0.06444	0.05111	0.04667	0.06000	0.06889
Q9	0.06889	0.03778	0.08222	0.05111	0.06444	0.06000	0.06444	0.07333	0.00000	0.05556	0.06444	0.04667	0.05111	0.06000	0.04222	0.06000	0.06444
Q10	0.06444	0.06000	0.05111	0.04667	0.05111	0.05111	0.06000	0.06444	0.05556	0.00000	0.06444	0.06000	0.06000	0.06000	0.06000	0.04667	0.06000
Q11	0.05111	0.06444	0.04667	0.04222	0.06444	0.06000	0.07333	0.06444	0.07333	0.04222	0.00000	0.07333	0.05556	0.05556	0.05556	0.06444	0.06444
Q12	0.04222	0.05111	0.05111	0.05111	0.06000	0.04667	0.07778	0.05111	0.07778	0.06000	0.07333	0.00000	0.06000	0.07333	0.06889	0.06889	0.06889
Q13	0.05556	0.04222	0.05444	0.04667	0.05111	0.04667	0.05556	0.06000	0.06000	0.06889	0.05111	0.06444	0.00000	0.05111	0.06000	0.06444	0.06444
Q14	0.06444	0.05111	0.07333	0.04667	0.07111	0.04222	0.06444	0.06000	0.05111	0.06889	0.05111	0.06000	0.05556	0.00000	0.04222	0.05111	0.04000
Q15	0.05556	0.05556	0.06889	0.05111	0.05111	0.07778	0.06000	0.07333	0.06889	0.05111	0.04667	0.05556	0.05111	0.06000	0.00000	0.06889	0.07333
Q16	0.04667	0.06444	0.06889	0.05556	0.06889	0.06000	0.06000	0.05111	0.07333	0.05556	0.06000	0.04667	0.04667	0.05556	0.06000	0.00000	0.02222
Q17	0.05556	0.04222	0.06000	0.05111	0.06889	0.05556	0.06889	0.05556	0.06000	0.05556	0.07333	0.05556	0.06889	0.06000	0.05556	0.08222	0.01111

Table 5. D+R and D-R values for all components.

I-N	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
Q1	1.00000	-0.04222	-0.05111	-0.05556	-0.06444	-0.06889	-0.06889	-0.07333	-0.05556	-0.06000	-0.06000	-0.06444	-0.05556	-0.05556	-0.05111	-0.06444	-0.06000
Q2	-0.04667	1.00000	-0.06000	-0.06000	-0.06444	-0.07333	-0.05556	-0.06444	-0.06000	-0.05111	-0.05111	-0.06000	-0.06444	-0.06889	-0.06000	-0.07778	-0.06889
Q3	-0.04222	-0.04222	1.00000	-0.06000	-0.05111	-0.05556	-0.06444	-0.06000	-0.04222	-0.04667	-0.05556	-0.05111	-0.04667	-0.05556	-0.06000	-0.07333	-0.06889
Q4	-0.06444	-0.06000	-0.08222	1.00000	-0.04222	-0.05111	-0.08667	-0.06444	-0.06444	-0.06889	-0.06889	-0.06000	-0.05556	-0.03778	-0.06000	-0.07778	-0.05556
Q5	-0.06444	-0.04222	-0.06444	-0.06000	1.00000	-0.07111	-0.05556	-0.05556	-0.06444	-0.06444	-0.06444	-0.06444	-0.06444	-0.05556	-0.06000	-0.05111	-0.05111
Q6	-0.05556	-0.04222	-0.06000	-0.06889	-0.05111	1.00000	-0.06889	-0.06000	-0.06000	-0.06444	-0.06444	-0.06000	-0.05111	-0.05111	-0.06444	-0.05556	-0.06000
Q7	-0.05111	-0.05556	-0.04667	-0.06000	-0.06000	-0.06889	1.00000	-0.05111	-0.07333	-0.05556	-0.05556	-0.06444	-0.06444	-0.07333	-0.06889	-0.06889	-0.06000
Q8	-0.04667	-0.03778	-0.06889	-0.05556	-0.06889	-0.06000	-0.06444	1.00000	-0.05111	-0.04667	-0.05111	-0.06000	-0.06444	-0.05111	-0.04667	-0.06000	-0.06889
Q9	-0.06889	-0.03778	-0.08222	-0.05111	-0.06444	-0.06000	-0.06444	-0.07333	1.00000	-0.05556	-0.06444	-0.04667	-0.05111	-0.06000	-0.04222	-0.06000	-0.06444
Q10	-0.06444	-0.06000	-0.05111	-0.04667	-0.05111	-0.05111	-0.06000	-0.06444	-0.05556	1.00000	-0.06444	-0.06000	-0.06000	-0.06000	-0.06000	-0.04667	-0.06000
Q11	-0.05111	-0.06444	-0.04667	-0.04222	-0.06444	-0.06000	-0.07333	-0.06444	-0.07333	-0.04222	1.00000	-0.07333	-0.05556	-0.05556	-0.05556	-0.06444	-0.06444
Q12	-0.04222	-0.05111	-0.05111	-0.05111	-0.06000	-0.04667	-0.07778	-0.05111	-0.07778	-0.06000	-0.07333	1.00000	-0.06000	-0.07333	-0.06889	-0.06889	-0.06889
Q13	-0.05556	-0.04222	-0.05444	-0.04667	-0.05111	-0.04667	-0.05556	-0.06000	-0.06000	-0.06889	-0.05111	-0.06444	1.00000	-0.05111	-0.06000	-0.06444	-0.06444
Q14	-0.06444	-0.05111	-0.07333	-0.04667	-0.07111	-0.04222	-0.06444	-0.06000	-0.05111	-0.06889	-0.05111	-0.06000	-0.05556	1.00000	-0.04222	-0.05111	-0.04000
Q15	-0.05556	-0.05556	-0.06889	-0.05111	-0.05111	-0.07778	-0.06000	-0.07333	-0.06889	-0.05111	-0.04667	-0.05556	-0.05111	-0.06000	1.00000	-0.06889	-0.07333
Q16	-0.04667	-0.06444	-0.06889	-0.05556	-0.06889	-0.06000	-0.06000	-0.05111	-0.07333	-0.05556	-0.06000	-0.04667	-0.04667	-0.05556	-0.06000	1.00000	-0.02222
Q17	-0.05556	-0.04222	-0.06000	-0.05111	-0.06889	-0.05556	-0.06889	-0.05556	-0.06000	-0.05556	-0.07333	-0.05556	-0.06889	-0.06000	-0.05556	-0.08222	0.98889

Table 6. The degree of influence or impact of factors.

(I-N) ^-1	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
Q1	1.94884	1.08479	0.95258	0.96551	0.96287	0.97927	1.00593	0.95041	1.02811	1.01038	1.08646	0.98234	1.00124	0.89871	1.02442	0.82390	0.91376
Q2	0.88612	1.92626	0.88341	0.88780	0.86973	0.89600	0.91745	0.87740	0.96067	0.92940	0.99549	0.91151	0.92463	0.83422	0.95452	0.78018	0.83613
Q3	0.99826	1.06255	1.89016	0.95585	0.93743	0.96895	0.97219	0.93681	1.02491	1.01636	1.06790	0.99243	0.97543	0.89034	1.02278	0.82678	0.90446
Q4	0.89899	0.97156	0.86465	1.83236	0.87525	0.90513	0.90670	0.88650	0.93728	0.93364	0.99606	0.89190	0.92376	0.82313	0.95424	0.76529	0.84890
Q5	0.92515	0.98835	0.88447	0.88510	1.82659	0.91285	0.91121	0.89044	0.95011	0.93803	0.99295	0.89991	0.91030	0.82662	0.94212	0.76103	0.84487
Q6	1.00764	1.07699	0.96778	0.98155	0.95863	1.93020	1.00948	0.95785	1.04795	1.01052	1.09841	0.97817	0.99717	0.90181	1.02075	0.83518	0.90562
Q7	0.97705	1.04424	0.93024	0.93972	0.92905	0.97204	1.91420	0.91613	1.01607	0.99460	1.06507	0.96366	0.97436	0.87000	0.98871	0.82390	0.88822
Q8	0.94011	0.99246	0.90195	0.91092	0.90103	0.92755	0.94109	1.84340	0.96504	0.96100	1.01695	0.92239	0.92880	0.84333	0.95784	0.79220	0.86964
Q9	0.96843	1.03095	0.90995	0.93454	0.91668	0.94008	0.96633	0.91984	1.93763	0.99413	1.04828	0.95490	0.96562	0.87039	1.01161	0.79274	0.89651
Q10	0.93400	0.99005	0.87770	0.88960	0.89201	0.91400	0.91635	0.87566	0.94727	1.88603	1.00645	0.91668	0.93090	0.83961	0.96021	0.76084	0.84138
Q11	0.99550	1.07246	0.96394	0.97714	0.95846	0.98663	0.98966	0.95055	1.03952	1.00651	2.02173	0.99380	0.99271	0.90646	1.01297	0.83541	0.90990
Q12	0.96068	1.02285	0.92621	0.92277	0.91269	0.94785	0.96229	0.92393	0.99080	0.97819	1.04803	1.89422	0.94896	0.88225	0.98762	0.79401	0.88095
Q13	0.96533	1.03189	0.93416	0.93873	0.93640	0.96428	0.97478	0.93621	1.00742	0.98717	1.04965	0.97293	1.91268	0.88568	1.00436	0.80402	0.90050
Q14	1.01171	1.10214	0.97528	0.96462	0.96915	1.00192	1.02087	0.97988	1.05169	1.03817	1.12333	0.99785	0.99616	1.86774	1.06364	0.85609	0.93863
Q15	0.91004	0.97687	0.86696	0.87081	0.85348	0.88271	0.89657	0.85283	0.91530	0.91875	0.98097	0.88972	0.89181	0.82219	1.87173	0.74596	0.81569
Q16	1.00995	1.08775	0.96254	0.97938	0.96493	0.98914	0.99235	0.95280	1.03420	1.02480	1.08155	1.00432	1.00339	0.91281	1.03172	1.78815	0.91159
Q17	0.97099	1.04183	0.92463	0.93725	0.92721	0.96259	0.96915	0.93051	0.99801	1.00069	1.05950	0.96939	0.97208	0.88031	0.99066	0.80264	1.83811

Table 7. Specifying a possible hierarchy or structure of criteria.

N*(I-N) ^-1	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	ssum
Q1	0/970990787	1/004183	0/092463	0/093725	0/092721	0/096259	0/096915	0/093051	0/099801	1/000069	1/005950	0/096939	0/097208	0/088031	0/099066	0/080264	0/083811	14/366
Q2	1/000995	1/008775	0/096254	0/097938	0/096493	0/098914	0/099235	0/095280	1/003420	1/002480	1/008155	1/000432	1/000339	0/091281	1/003172	0/078815	0/091159	14/810
Q3	0/091004	0/097687	0/086696	0/087081	0/085348	0/088271	0/089657	0/085283	0/091530	0/091875	0/098097	0/088972	0/089181	0/082219	0/087173	0/074596	0/081569	13/237
Q4	1/001171	1/010214	0/097528	0/096462	0/096915	1/000192	1/002087	0/097988	1/005169	1/003817	1/012333	0/099785	0/099616	0/086774	1/006364	0/085609	0/093863	15/009
Q5	0/096533	1/003189	0/093416	0/093873	0/093640	0/096428	0/097478	0/093621	1/000742	0/098717	1/004965	0/097293	0/091268	0/088568	1/000436	0/080402	0/090050	14/340
Q6	0/096068	1/002285	0/092621	0/092277	0/091269	0/094785	0/096229	0/092393	0/099080	0/097819	1/004803	0/089422	0/094896	0/088225	0/098762	0/079401	0/088095	14/143
Q7	0/099550	1/007246	0/096394	0/097714	0/095846	0/098663	0/098966	0/095055	1/003952	1/000651	1/002173	0/099380	0/099271	0/090646	1/001297	0/083541	0/090990	14/708
Q8	0/093400	0/099005	0/087770	0/088960	0/089201	0/091400	0/091635	0/087566	0/094727	0/088603	1/000645	0/091668	0/093090	0/083961	0/096021	0/076084	0/084138	13/603
Q9	0/096843	1/003095	0/090995	0/093454	0/091668	0/094008	0/096633	0/091984	0/093763	0/099413	1/004828	0/095490	0/096562	0/087039	1/001161	0/079274	0/089651	14/194
Q10	0/094011	0/099246	0/090195	0/091092	0/090103	0/092755	0/094109	0/084340	0/096504	0/096100	1/001695	0/092239	0/092880	0/084333	0/095784	0/079220	0/086964	13/806
Q11	0/097705	1/004424	0/093024	0/093972	0/092905	0/097204	0/091420	0/091613	1/001607	0/099460	1/006507	0/096366	0/097436	0/087000	0/098871	0/082390	0/088822	14/342
Q12	1/000764	1/007699	0/096778	0/098155	0/095863	0/093020	1/000948	0/095785	1/004795	1/001052	1/009841	0/097817	0/099717	0/090181	1/002075	0/083518	0/090562	14/772
Q13	0/092515	0/098835	0/088447	0/088510	0/082659	0/091285	0/091121	0/089044	0/095011	0/093803	0/099295	0/089991	0/091030	0/082662	0/094212	0/076103	0/084487	13/520
Q14	0/089899	0/097156	0/086465	0/083236	0/087525	0/090513	0/090670	0/088650	0/093728	0/093364	0/099606	0/089190	0/092376	0/082313	0/095424	0/076529	0/084890	13/467
Q15	0/099826	1/006255	0/089016	0/095585	0/093743	0/096895	0/097219	0/093681	1/002491	1/001636	1/006790	0/099243	0/097543	0/089034	1/002278	0/082678	0/090446	14/541
Q16	0/088612	0/092626	0/088341	0/088780	0/086973	0/089600	0/091745	0/087740	0/096067	0/092940	0/099549	0/091151	0/092463	0/083422	0/095452	0/078018	0/083613	13/549
Q17	0/094884	1/008479	0/095258	0/096551	0/096287	0/097927	1/000593	0/095041	1/002811	1/001038	1/008646	0/098234	1/000124	0/089871	1/002442	0/082390	0/091376	14/757
J sum	14/38894	15/37738	13/73940	13/87091	13/70152	14/13935	14/29153	13/70022	14/82587	14/61729	15/59282	14/18439	14/27670	12/97658	14/78482	11/96179	13/19300	

Table 8. Drawing a Cartesian coordinate diagram.

	R+J	R-J
Q1	28/75540793	-0/022478738
Q2	30/18721371	-0/567548193
Q3	26/97606799	-0/502733538
Q4	28/87944832	1/137635548
Q5	28/04188758	0/638848761
Q6	28/28201001	0/003312105
Q7	28/99948088	0/416418567
Q8	27/30359877	-0/096846318
Q9	29/01955185	-0/632184799
Q10	28/42324632	-0/811336562
Q11	29/93480937	-1/250824224
Q12	28/95684195	0/588065523
Q13	27/79678731	-0/756617301
Q14	26/44402427	0/490869351
Q15	29/32568795	-0/243943254
Q16	25/51046267	1/586884334
Q17	27/94991	1/563909395

Based on the data presented in Table 8, a Cartesian coordinate system was constructed, wherein the horizontal axis represents the R+J values and the vertical axis corresponds to the R-J values. Each factor's position was subsequently plotted as a point with coordinates (R+J, R-J) within this system. This methodology facilitated the generation of a visual representation in the form of a graphical diagram, enabling a comprehensive analysis of the relationships between variables (Fig 3).

The DEMATEL technique offers a structured approach to analyzing and interpreting the complex interdependencies and influences among various factors that affect production and industrial operations. By mapping out these relationships, DEMATEL helps in understanding the critical dynamics that underpin industrial processes. This analysis provides valuable insights into the hierarchical structure of factors, their causal relationships, and the potential impact they have on each other (Fig3). Understanding these relationships is essential for effective strategic planning, risk management, and operational efficiency in industrial settings.

The DEMATEL technique analysis and interpretation reveal several critical insights into the interdependencies

and influences among various factors affecting production and industrial operations:

1. Impact factors (R):
- The top five features influencing other factors are:
  1. Change in demand level.
  2. Delay in product delivery.
  3. Unacceptable quality and non-conformities in production.
  4. Disclosure of production information.
  5. Incompatibility of product components with the overall product or system.

2. Receiving factors (J):
- The features most influenced by others include:
  1. Delay in the supply of materials and parts.
  2. Risks from production machinery due to untimely repairs and calibration.
  3. Unsuccessful transfer of the production line after the contract period ends.

3. Interrelation (R+J):
- The four features with the highest interaction with other factors are:
  1. Currency fluctuations (Q2).
  2. Disruption in the production system and industrial sabotage (Q11).
  3. Dependency on collaborative R&D companies in production (Q15).
  4. Non-compliance with regulations (Q9).

4. Net Effect (R-J):
- The most influential factors are:
  1. Inability to attract necessary production capital (Q16).
  2. Incompatibility of product parts with the overall product or system (Q17).
  3. Change in demand level (Q4).

- The most affected components are:
  1. Disruption in the production system and industrial sabotage (Q11).
  2. Violation of intellectual property laws (Q10).
  3. Unsuccessful transfer of the production line after a specified period (Q13).

The analysis highlights that factors like demand changes, product delivery delays, and production quality issues significantly impact the production ecosystem.

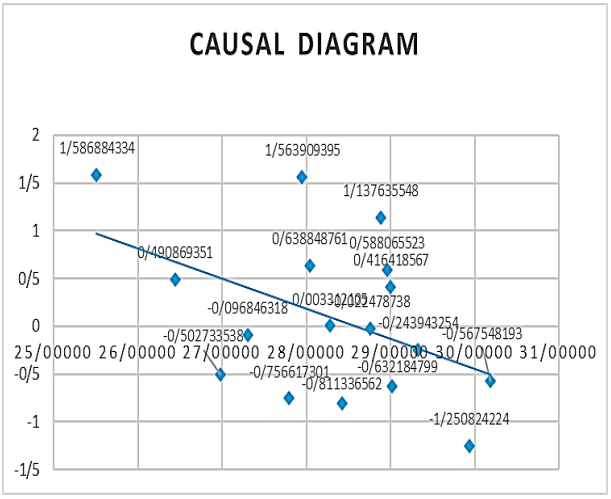


Figure 3: Causal diagram.

Conversely, supply chain delays, machinery maintenance issues, and post-contract production line transfers are highly susceptible to these impacts. Additionally, financial and regulatory compliance issues, along with system disruptions, show a high level of interrelation, suggesting a complex network where changes in one area can significantly affect multiple others. This understanding is crucial for strategic planning and risk management in industrial settings, emphasizing the need for integrated management approaches to mitigate these interlinked challenges effectively.

5. Conclusion

The application of the DEMATEL technique in analyzing production contracts within the construction industry underscores the intricate web of interdependencies and influences among various factors that dictate the success and efficiency of construction operations. The findings reveal several critical insights pertinent to the management of production contracts in this sector.

Firstly, the impact factors identified, such as changes in demand levels, delays in product delivery, and issues of unacceptable quality, are paramount in shaping the dynamics of production contracts. These factors underscore the necessity for flexible and adaptive contract terms that can accommodate fluctuations in demand and delivery schedules while maintaining quality standards. Construction projects are inherently subject to various external and internal influences that can alter project timelines and scopes, thus making it essential for contracts to incorporate clauses that address such variables.

Secondly, receiving factors like delays in the supply of materials and parts, risks from machinery due to untimely repairs, and unsuccessful transfer of production lines after the contract period emphasize the vulnerability of construction operations to supply chain disruptions and maintenance issues. Contracts should therefore include stringent provisions for timely supply deliveries and comprehensive maintenance schedules to mitigate these risks. Furthermore, clauses that ensure smooth transitions and transfers of production lines, especially in modular and prefabricated construction, are crucial for maintaining operational continuity.

The interrelation analysis highlights the significant interactions among currency fluctuations, production system disruptions, dependency on collaborative R&D companies, and non-compliance with regulations. For construction contracts, this suggests a need for integrated financial and operational risk management strategies. Currency fluctuations, for instance, can impact both the cost and availability of materials and labor. Hence, contracts should include financial hedging mechanisms and clear stipulations for currency risk management. Additionally, given the high dependency on collaborative R&D for innovation in construction techniques and materials, contracts should facilitate collaborative efforts and clearly define the intellectual property rights and responsibilities.

Finally, the net effect analysis indicates that factors such as the inability to attract necessary production capital, incompatibility of product parts, and changes in demand levels are most influential, while disruptions in the production system, intellectual property violations, and unsuccessful production line transfers are most affected. This insight points to the need for robust strategic planning and risk management in construction contracts. Integrated management approaches that consider the holistic impact of these interlinked factors can help in crafting more resilient and adaptive contracts. By anticipating potential disruptions and planning for contingencies, stakeholders can better manage the complexities inherent in construction projects, ensuring operational efficiency and project success.

In conclusion, the DEMATEL analysis provides a comprehensive framework for understanding the intricate relationships among factors that influence production contracts in the construction industry. It emphasizes the importance of flexible, integrated, and forward-thinking contract management strategies to navigate the multifaceted challenges of modern construction operations.

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Conflict of Interest

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