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# Identifying the Key Causes and Impacts of Variation Orders in Iraqi Construction Projects

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**ABSTRACT**

Variation Orders is often a reason for construction projects exceeding projects budget and delays; it is a global problem, particularly intensive in the case of a recession of the local economy and stagnation. In Iraq, all the projects have delays in completion, and the cost affects because of the variation orders, which are not well managed. The objective of this study was to identify the key causes responsible for the variation order in construction projects in Iraq using the system dynamic. System's dynamics is the discipline of academics and rooted initially been in management and the engineering sciences. The data relating to the performance of construction projects from 27 projects adopted by Diyala University were collected. Personal interviews and questionnaires survey to the selected projects of specialized engineers were done. The results revealed that the size of variation orders in Iraqi construction projects was high, and 13 key causative factors led to variation orders. The variation in cost was the most influential factor effecting the construction project in Iraq. When variation orders in a cost increased, the owner's opinion decreased. When the external factors increased, cost variation orders increased. It was concluded that minimizing the variation orders was very important to realize the cost in the construction projects. Therefore, the authority management and project managers must make a plan to address these key causes in future projects to ensure their success.

## 1. Introduction

Variation Order (VO) is a common phenomenon in construction projects. It involves an amendment of the original scope of work as in the contract [1]. Variations often cause disputes and dissatisfactions among the parties involved in construction projects. Thus, it is imperative to control VOs in a construction project [2]. Tayeh et al., 2020, identified the causes of VO as lack of materials and equipment spare parts due to closure, change in design by a consultant, lack of consultant's knowledge of available materials, errors and omission in design, conflicts between contract documents, owner's financial problems, lack of coordination among project parties, using the inadequate specification for local markets by an international consultant, internal politics, and change is a specification by owners [3]. Odenigbo et al., 2020, suggested the causes of VO as client, consultant, contractors, and others. Ghafoor et al., 2020, stated that the essential steps in developing a variation order are the scope definition. A poorly defined scope will not provide a clear baseline, leading to the variation order that will be evaluated within or outside the scope [4], [5].

Hassana et al., 2018, suggested that consultants should understand the overall scope and goals of the project. However, the consultant's feeling of superiority over the contractor may prevent the consultant from

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giving attention to the contractor's requests [6]. According to Hassan et al., 2018, Contractors may discover discrepancies, omissions, errors, and conflicts in the documents and request a consultant's opinion regarding the problem. A variation order will then be issued with additional costs to solve the problem [7]. Enshassi et al., 2010 stated that variation order affected the project performance as it will affect productivity and the project costs [8].

Simulation granted the power to variation a system during the time and analyzed it in numerous various conditions [9]. The Dynamics System is an analysis of system path originated through Forrester to analyzing and modeling the behavior of complex systems of social in the context of industrial [10]. The dynamic system model was adopted by Kim et al., 2021 in general project management to model project and client relationships in construction [11]. Asiedu et al., 2020 attempted to improve management for the projects' design stage [12].

The construction projects in Iraq suffer from complex problems make it difficult for projects to progress either in new projects or in the rehabilitation of existing projects. Variation orders are present in significant proportions in construction projects and negatively impact projects, and there is a weakness among project managers who are managing variation orders.

The objective of this study was to identify the key causes and variation orders in the construction projects in Iraq using the system dynamic.

## 2. Methodology

The questionnaire prepared using data obtained from the theoretical side, and the case studies, open questionnaire for the purpose identified in detail the degree of effect for each reason on the final result is a regular survey of the opinions of the selected sample of experienced engineers in the field of construction projects. The researcher has chosen groups of arbitrators who comply with scientific, academic, and professional characteristics.

Eighty Questionnaire forms were distributed to engineering specialists and engineering experts in construction project implementation and management in Iraq. However, seventy questionnaire forms were adopted in the analysis and assessed because some of the receipt forms were marginal and imperfect responses or not filled. Table1 illustrates the distribution of the questionnaire forms

**Table 1:** Distribution of forms for the questionnaire

| Company’s Name | Distributed | Received |
|---|---|---|
| The Ministry of Higher Education and Scientific Research | 11 | 10 |
| Directorate of Roads and Bridges | 15 | 13 |
| Ministry of Construction and Housing and Public Works | 23 | 20 |
| Ministry of Education - School Buildings Directorate | 31 | 27 |
| Total | 80 | 70 |

Firstly, personal visits and meetings were conducted with each engineer, studying and discussing the contents of the questionnaire form to resolve any misunderstanding of the issues if the questions were unknown. Secondly, all responses were fully checked to ensure that the questionnaire form was completed. Thirdly, statistical analysis using statistical package social science (SPSS) program V.25 to validate the questionnaires' reliability. Relative Impact Strength Index and Chronbach's Impact Strength Alpha for each factor according to the participants were identified using SPSS. Arithmetic means to rank the responses; a hypothetical weight value (WV) was identified for each five-scale Likert response established in this questionnaire. as illustrated in Table 2 and using Eq. 1 like, [13].

If the alpha value is high (close to one), the high reliability of the questionnaire is already indicated. Coefficient alpha the degree of internal consistency of the scale between (0- 1).

The Cronbach Alpha coefficient hence should be no less than (0.70) [14].

**Table 2:** Value of descriptive frequencies by weight

| Informative Frequency Description | The Class Interval (C.I.) | The Weight Value (WV) |
|---|---|---|
| Very low | $1 \leq$ C. I.$\leq 1.8$ | 1 |
| Low | $1.8 <$ C. I.$\leq 2.6$ | 2 |
| Medium | $2.6 <$ C. I.$\leq 3.4$ | 3 |
| High | $3.4 <$ C. I.$\leq 4.2$ | 4 |
| Very high | $4.2 <$ C. I.$\leq 5$ | 5 |

$$AM = \frac{\Sigma\,(Weight\ Value\ for\ particular \times number\ of\ frequencies)}{Total\ number\ of\ the\ answers} \quad (1)$$

The system dynamics model was adopted to assess the owner, contractor, and legislative impact on construction projects' performance using the free software system VENSIM PLE to visualize the model. The interconnection among variables in the conceptual model was converted into quantitative measures using the VENSIM PLE free computer system through the stock and flow diagram. A model containing a stock and flow diagram one model impacts variation orders cost on construction projects was adopted in this article.

## 3. Results

### *3.1 Information on questionnaire respondents*

Figure 1 shows the answers to the questions related to the characteristics of the participants. The answers were based on the work sector of the academic degree, workplace, group specialty, years of work experience, and engineering field specialties were given in figures (2-6), respectively.

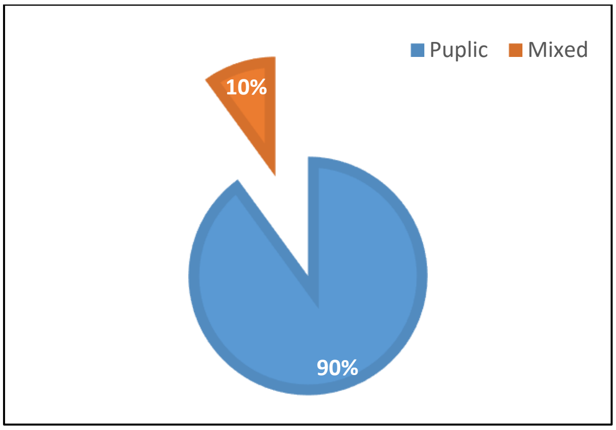


**Figure 1.** Work sector

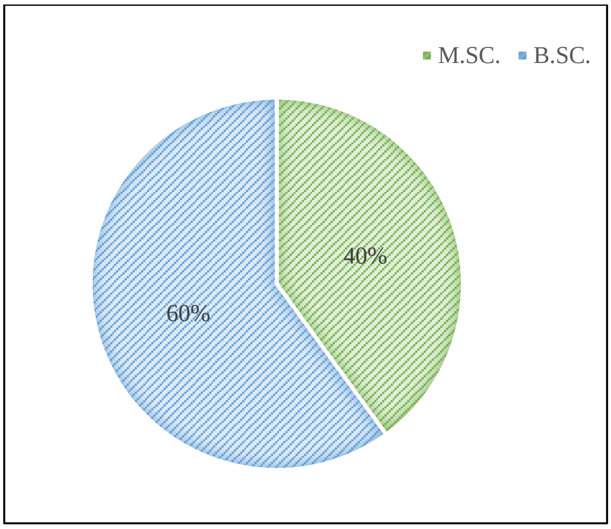


**Figure 2.** Academic degree

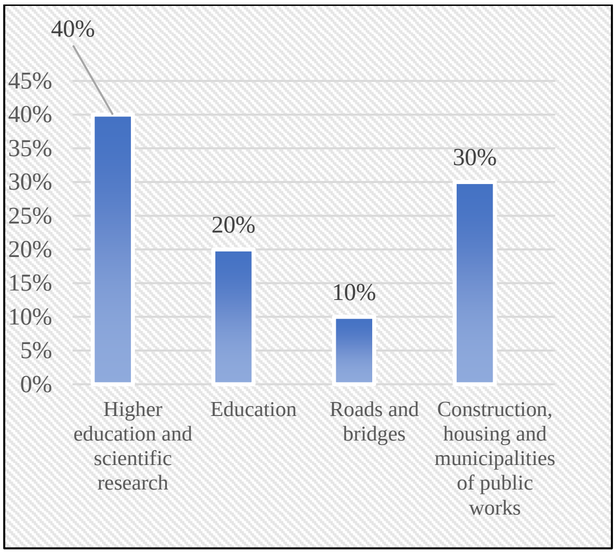


**Figure 3.** Work place

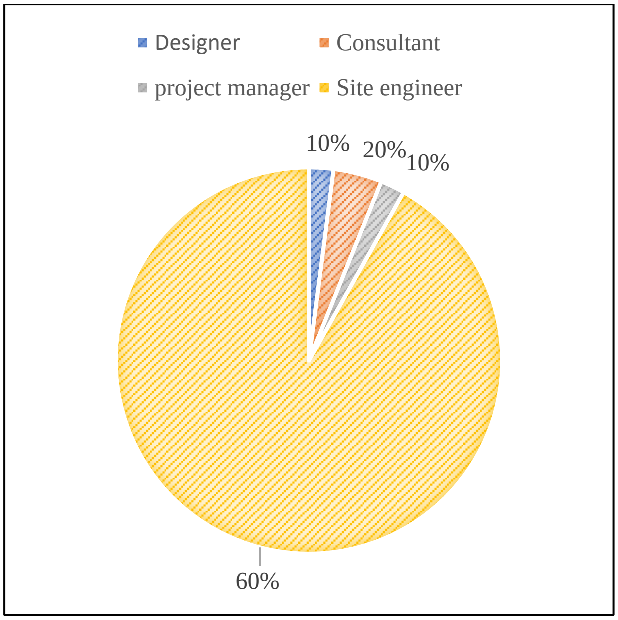


**Figure 4.** Group specialty

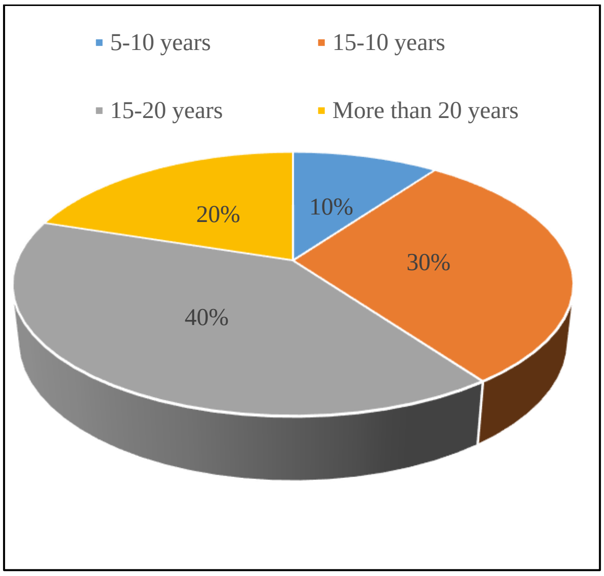


**Figure 5.** Years of work experience

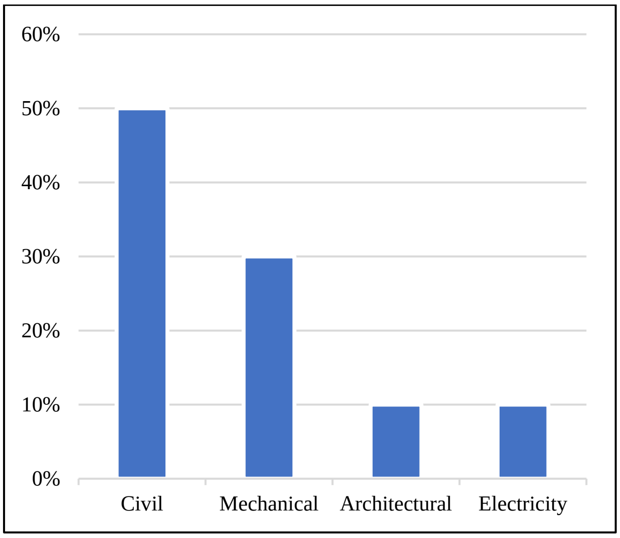


**Figure 6.** Engineering field

The results obtained from this section showed that the sample size was from different engineering fields, and most respondents have experience in the construction field for more than 15 years and have a different working place and specialty. So, this sample size considers appropriate for this study.

*3.2 Current practices and knowledge*

It was demonstrated from the questionnaires that lots of changes in the orders occurred in most construction projects. However, more than 60 percent of engineers didn't handle the variation orders properly. Therefore, an efficient management system responsible for managing the variation order was absent in the construction projects.

It is demonstrated by Figure 7 that around 90% of the average amount of variation ranged in 10-30 % of the total cost of the construction projects.

According to Table 3, 43 factors were identified to be the causes of the variation order. The Cronbach Alpha (α) was 0.955, indicating a high degree of reliability. The factors whose arithmetic mean less than 2.6 were excluded. Therefore, 13 key causative factors of variation orders in the selected construction projects were identified, as shown in Table 4.

For identifying the impact of variation orders, the value of Cronbach Alpha (α) for the engineers' answers was 0. 983, which indicates a high degree of reliability. According to Table 5, the arithmetic mean was 3.6 for the question" the delay project scheduling and completion", the arithmetic mean was 3.5 for the question "the increase in the project cost." Negative impacts in the selected construction projects were observed. They were attributed to bad management of variation orders on the project schedule, the project cost, delayed completion date, and increased project cost, as depicted by Table 5.

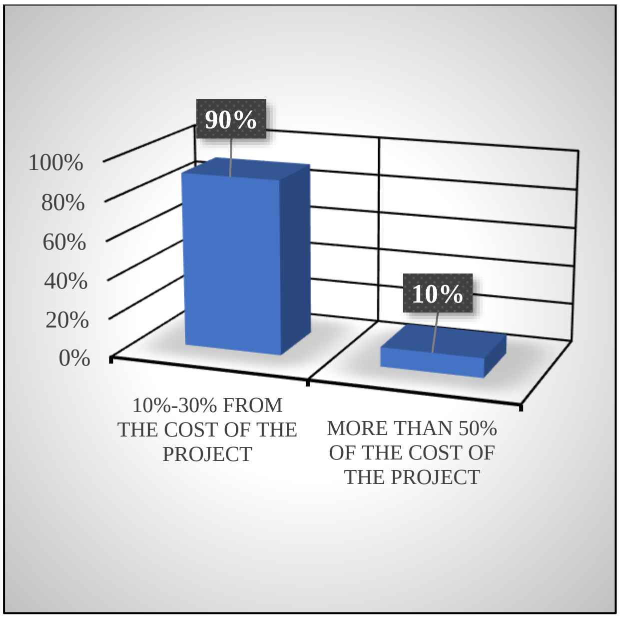


**Figure 7.** The average amount of variation cost impact

**Table 3:** A list of causes factors of variation orders

| NO. | Reasons for occurrence changes during the construction project |
|---|---|
| 1. | Weather conditions |
| 2. | Value Engineering |
| 3. | Unavailability of materials |
| 4. | The financial difficulties of the contractor |
| 5. | The design is incompatible with Owner requirements |
| 6. | The contractor's desire to improve his financial condition |
| 7. | The consultant's lack of knowledge of the available materials |
| 8. | The consultant's lack of judgment and experience. |
| 9. | The consultant lacks the required data |
| 10. | The consultant lacks historical data for the project |
| 11. | The complexity of the design |
| 12. | Replacement of materials by the contractor |
| 13. | Quality Assurance / Control |
| 14. | Poor knowledge of materials and equipment |
| 15. | Owner financial problems |
| 16. | Not to use a consultant for advanced engineering design programs. |
| 17. | Material changes by owner |
| 18. | Late a contractor in execution. |
| 19. | Lack of skills |
| 20. | Lack of flexibility for the consultant |
| 21. | Lack of design documentation |
| 22. | Lack of cost planning/control during pre-and post-contract phase |
| 23. | Lack of coordination between the parties in the project |
| 24. | Insufficient project activities |
| 25. | Incomplete design at bidding time |
| 26. | Inadequate work with drawing details |
| 27. | Honest wrong beliefs of a consultant |
| 28. | Health and safety considerations by the consultant |
| 29. | Errors and omissions in the design |
| 30. | Different site conditions |
| 31. | Design modification by the owner |
| 32. | Design change by the consultant |
| 33. | Design and drawing issues |
| 34. | Delays in production |
| 35. | Delay in conducting the examination and testing by the consultant |
| 36. | Conflict between contract documents |
| 37. | Change schedule |
| 38. | Change plans or scope |
| 39. | Change of plans or scope by owner |
| 40. | Change in work quantities |
| 41. | Change in specifications by the consultant |
| 42. | Change in design by the engineer or designer |
| 43. | A change in specifications by the owner |

**Table 4:** Key causative factors of variation orders

| NO. | Key Causes factors | Mean | Std. Deviation |
|---|---|---|---|
| 1. | Late a contractor in execution. | 3.3000 | 1.27802 |
| 2. | Errors and omissions in the design | 3.2000 | .75373 |
| 3. | The consultant's lack of judgment and experience. | 3.2000 | 1.17461 |
| 4. | Different site conditions | 3.1000 | 1.30939 |
| 5. | Incomplete design at bidding time | 3.1000 | 1.30939 |
| 6. | Owner financial problems | 3.1000 | 1.38470 |
| 7. | The consultant lacks historical data for the project | 3.0000 | 1.10335 |
| 8. | The financial difficulties of the contractor | 2.9000 | 1.22947 |
| 9. | The contractor's desire to improve his financial condition | 2.9000 | 1.30939 |
| 10. | Lack of skills | 2.8000 | 1.33623 |
| 11. | Change in work quantities | 2.7000 | 1.27802 |
| 12. | Lack of design documentation | 2.7000 | 1.27802 |
| 13. | Not to use a consultant for advanced engineering design programs. | 2.7000 | 1.27802 |

**Table 5:** The key impact of variation orders

| No. | Key Impacts | Mean | Std. Deviation |
|---|---|---|---|
| 1. | Delay in project scheduling completion | 3.6000 | 1.43860 |
| 2. | The increase in the project cost | 3.5000 | 1.21285 |
| 3. | Adding funds to the contractor | 3.2000 | 1.48031 |
| 4. | Lack of planning strategies | 3.1000 | 1.38470 |
| 5. | lead to disputes | 3.0000 | |
| 6. | The increase in overhead expenses | 2.9000 | 1.22947 |
| 7. | The contractor's financial difficulties | 2.9000 | .95021 |
| 8. | Delay in payment | 2.7000 | 1.10794 |

*3.3 The model of cost variation orders*

*3.3.1. Conceptual model description for cost*

In this study, the conceptual model described the dynamic procedure of the system variable relationship the model describing the variation orders process through construction projects is illustrated in Figure 8.

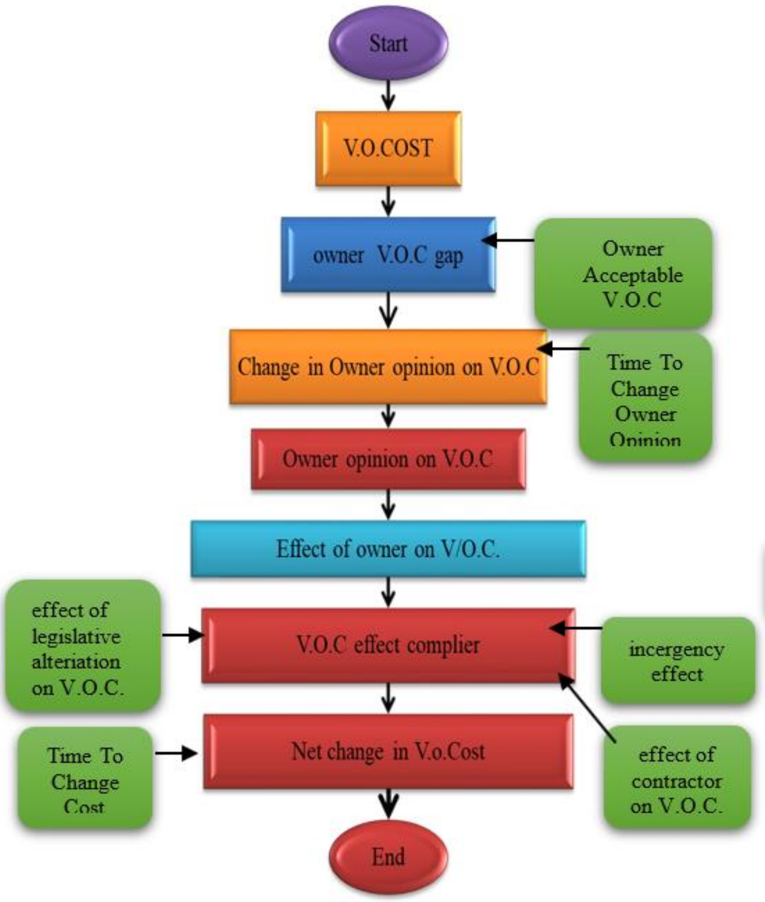


**Figure 8.** Balancing causal loop diagram effect of the owner on variation orders cost in a construction project

In the conceptual model description for cost, two reinforcing causal loop diagrams CLD and two Balancing causal loop diagrams. Figure 8 describes the Balancing Causal loop diagram effect of the owner on variation order cost in a construction project. When variation orders in a cost increased, the owner's opinion decreased due to the owner's negative effect. Figure 9 identifies the Reinforcing Causal loop diagram of the external factors for cost variation orders in a construction project. When the external factors increased, cost variation orders increased. Figure 10 describes the contractor's Balancing Causal Loop diagram effect on variation order cost in a construction project. When variation orders of cost increased, contractor opinion decreased; thus, contractor performance influenced the construction projects. The cost factor was one of the essential indicators of the excellent completion of the project, and the increase in costs beyond a certain limit causes distress for all employees and disputes between owners and contractors; Figure 11 describes reinforcing Causal loop diagram of the emergency like war and impact for cost variation orders in a construction project. For a change in construction projects, variation orders on cost vary from project to project according to the project's size.

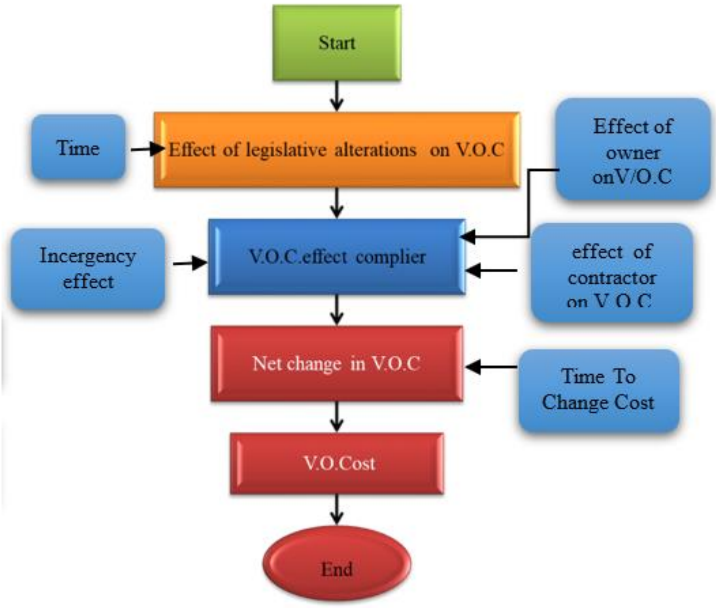


**Figure 9.** Reinforcing causal loop diagram of the external factors for cost variation orders in a construction project

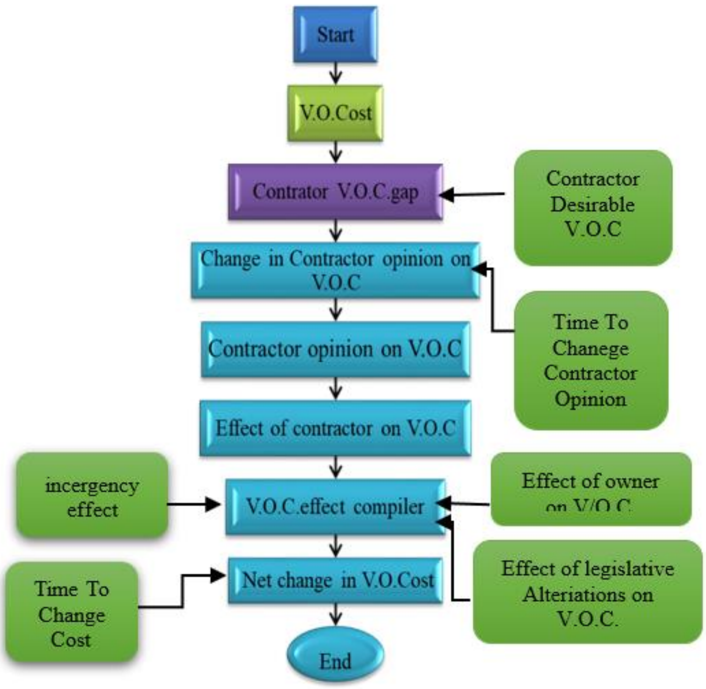


**Figure 10.** Balancing causal loop diagram effect of the contractor on variation orders cost in a construction project

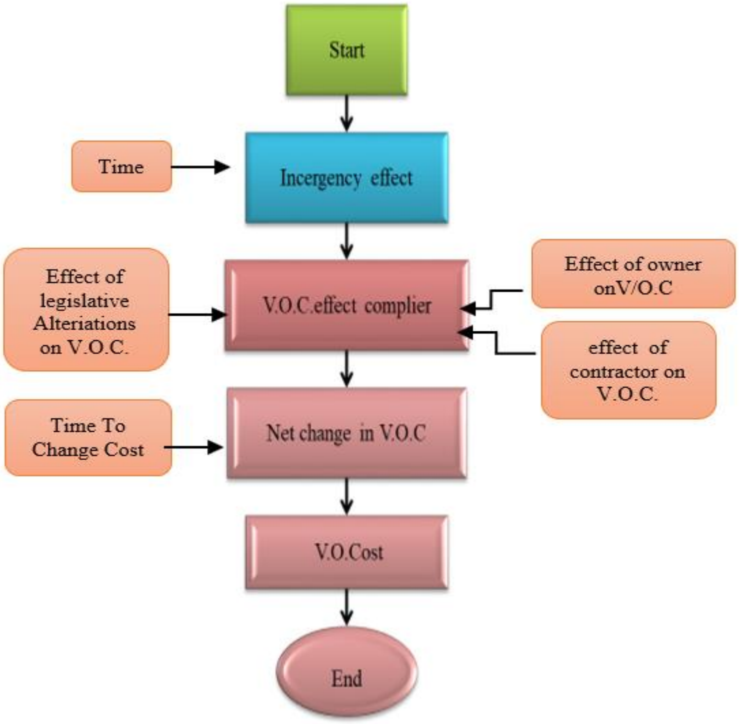


**Figure 11.** Reinforcing causal loop diagram of the external factors for cost variation orders in a construction project

*3.3.2 The dynamic system model of cost variation orders*

The interconnection among variables in the conceptual model was converted into quantitative measures using the VENSIM PLE free computer system through the stock and flow diagram. Figures 12-15 show the model describing variation order cost in the construction project in Iraq. The model was represented through stocks and flows whereby, addressing variation orders cost, contractor order's opinion on variation orders cost, owner opinion on variation orders cost, change in contractor opinion on variation orders cost, change in owner opinion on variation orders cost, and net change in variation. The model assessment was carried out using the dimensional verify identity expressed by the free software package VENSIM PLE. VENSIM gives awareness that the dimensions of auxiliaries, stocks, units, constants are reliable, and equations.

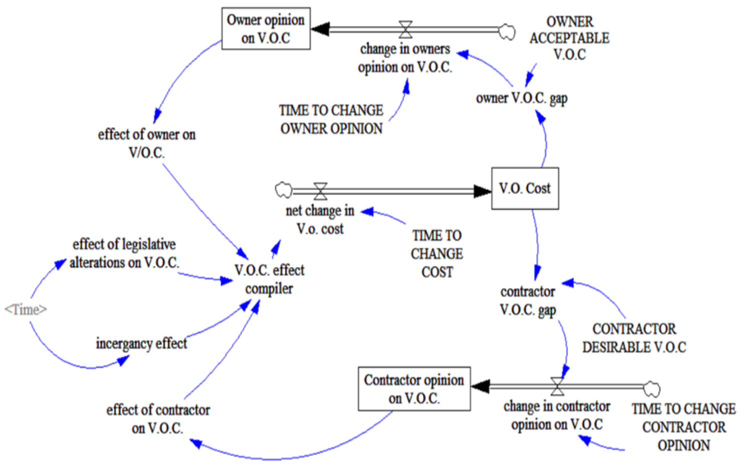


**Figure 12.** Variation orders cost in the construction project

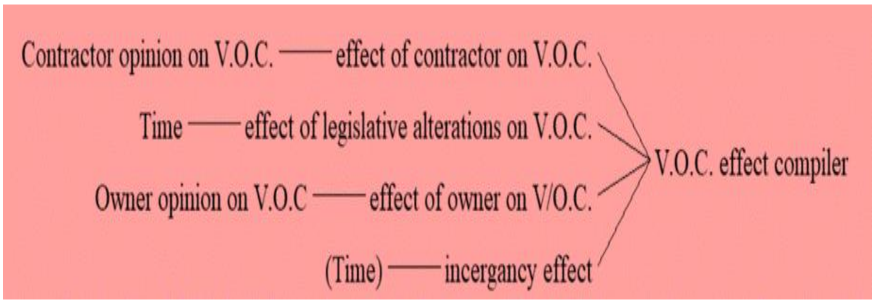


**Figure 13.** Causes diagram tree of effect compiler on variation orders cost

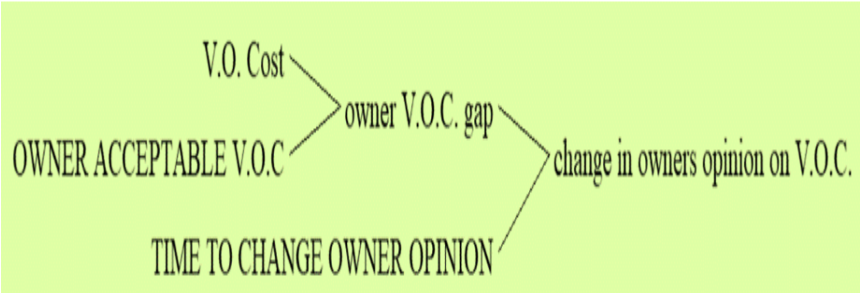


**Figure 14.** Causes diagram tree of change in owner opinion on variation orders cost

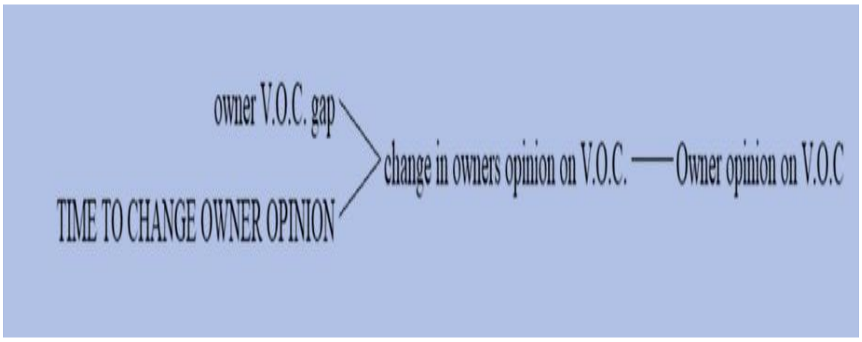


**Figure 15.** Causes diagram tree of owner opinion on variation orders cost

## 4. Conclusions

Based on the investigations done in this study, the following conclusion can be drawn:

1. It was found that most of the variation orders were of the malicious type increased the cost due to the owner's requirements, and a little of it was used to improve quality.
2. From the questionnaires, 43 causes of variation orders and ten impacts from the closed questionnaire. There was a negative impact on variation orders in large proportions in Iraqi construction projects.
3. The owner interferes, especially in adding new items and works or modifying the plans and the specifications, whether (dimensions - levels - places - materials) were among the main reasons issued the implementation of variation orders that increase the cost of the original project. It indicated the owner was poorly informed and closely involved in the design stage of the project, and a lack of perception and appreciation of the party owing to the negative effects of variation orders, especially those related to a long time involved delays the completion of the project in the required time.
4. Minimizing the variation orders was very important to realize the cost in the construction projects.

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