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RESEARCH ARTICLE

Assessment of Causes Affecting Progress Schedules on Construction Investment Projects Funded by State Budget in Hanoi City, Vietnam

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Abstract:

Background:

Hanoi, the capital city, is the economic, political, and cultural center of Vietnam. Every year, the City's Government always spends a large part of the budget on construction investment in order to create a basis for promoting its economic development and improving the residents living standards. However, in the process of implementing investment and construction, many projects were delayed, leading to the failure to achieve the desired investment efficiency.

Objective:

To research and evaluate the causes affecting the progress schedules of construction projects using public investment capital in Hanoi, the authors conducted a survey and used the F-AHP method to analyze data collected data in order to obtain objective and accurate results on the research problem.

Methods:

The causes affecting the progress of construction projects are classified into four groups, including subjective causes from project participants and objective reasons.

Results:

The results show that the causes of the project participants have a stronger influence than the objective causes in which the causes related to the owner and the causes related to the contractor have the highest influence.

Conclusion:

Based on projects ' progress schedules, the resources are mobilized, the parties work together to promote the development of the project.

Keywords: Hanoi, Construction, Delays, Projects, Fuzzy, Progress Schedules, Vietnam.

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1. INTRODUCTION

Investment activities which use the state budget capital for socio-economic development. This is a tool of the State to regulate the economy, ensuring economic balance. The outstanding feature of construction investment projects which use the state budget capital is dominated by the main capital source policy. This can increase the influence of owners on the success of the project in general and the project's progress in particular.

Construction investment activities in Hanoi city are strongly taking place. Construction investment projects using public investment capital are always kept at a high level (Table **1**) [1 - 3]. The Hanoi government conducts regular reports and assessments of the overall investment in the city in order to accelerate the implementation and disbursement progress schedules of the projects. Most of the public investment capital is for public works and technical infrastructure projects.

Disbursement results of Hanoi city, according to the progress of construction projects as of August 31, 2022, reached at the rate of 29.3% of the assigned plan, lower than the national average which belonged to the group of provinces. The city has the lowest disbursement rate in the country. Many units have large capital but low disbursement rate, such as Management Board of Investment Projects for Construction of Technical and Agricultural Infrastructure (20.8%), Hanoi Urban Railway Management Board (18.5%), Dong Anh District People's Committee (27.2%), HoaiDuc District People's Committee (23.0%), Ung Hoa District People's Committee (18.2%) and 4 units have not yet disbursed.

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Table 1. Public investment capital over the years (billion VND).

Year	2018	2019	2020	2021 - 2022
Total government budget capital	42.748	39.865	44.049	62.315
Construction projects	2.974	3.156	4.757	-
- Transition projects	1.544	1.415	2.268	-
- New investment projects	1.430	1.741	2.489	-

Implementation progresses of many projects are currently behind planned schedules, including the pilot urban railway project in Hanoi city, the section Nhon - Hanoi Railway Station, and the project to build the Ring 2 elevated road. VinhTuy bridge axis - NgaTu So intersection, Hanoi Children's Palace project, urban railway project No. 2 Nam Thang Long - Tran Hung Dao section, Water supply project to improve and restore Tich River in Ba Vi. Projects that are behind schedule are a loss of resources and a waste of public investment. Hanoi has made public and transparent processing information for projects behind schedule. The causes of slow progress are being actively explored to handle and have appropriate solutions. Within the scope of the research, the authors will explore the causes affecting the progress of the construction project implementation phase.

2. LITERATURE REVIEWS

2.1. Related Studies

Time is an index that is easily measured and is remembered frequently by the more involved in the project. Based on the schedule plan, resources are mobilized and coordinated with each other. Therefore, the schedule is a closely binding condition between the parties in the project and is often the source of conflicts during project implementation. Studies on projects' progress schedules have been interesting in the world and are gradually gaining more attention in Vietnam. It is possible to mention the studies of J. Vijayalaxmi and Umair Khan [4] evaluating the factors affecting the time in construction projects. Mohamed SaadBajjou and AnasChafi [5] stated that delay is a common problem in construction projects. Jyh-Bin Yang and Shen-Fen Ou [6] using SEM model clearly showed the correlation between the main causes of delay in construction investment projects. In another aspect Aftab Hameed Memon, Ismail Abdul Rahman, MohdRazaki Abdullah, Ade Asmi Abdu Azis [7] found the relationship between schedule and cost, the causes of increased costs often have a direct impact on progress before affecting costs. RemonF.AzizAsmaaA.Abdel-Hakam [8] listed 293 causes of project delay, but only 20 main causes come from contractors and consultants that need attention and improvement. Mahamid [9] referred to the main factors affecting the time deviation in construction investment projects such as late payment by owners, and changes in construction laws. Some studies consider time as a blur variable in schedule planning. McCahon [10] considers time as triangular blurr numbers. Using blur set theory, the author finds a difference in the expected project completion time and the actual completion time. Ö Ökmen and A Öztaş [11] argued that construction activities are carried out under uncertain conditions, so the duration of the works is blur information. Stefan Chanas and Pawel Zielinski [12] suggested using a blur critical path in a schedule based on work activities with uncertain information.

In Vietnam, studies on construction projects' progress schedules have been interesting for researchers. It is to include Le Huy Tai, Tran Van Thong and Dang Cong Thuat, summarizing 31 factors affecting the completion progress of public investment projects in general. The authors show that capital management and progress are issues that strongly affect the ability to complete construction projects using public investment capital. Tran Hoang Tuan pointed out 12 factors affecting the project implementation progress in Can Tho province. Truong Cong Bang [13] used a fuzzy set to clarify input information when planning the progress of construction investment projects. Dinh Doan Tu [14 - 16] applied fuzzy set theory to make a project construction schedule, fuzzy numbers used are triangular or trapezoidal fuzzy numbers. Besides, a number of master theses have also studied factors affecting the progress schedules of construction projects, typically applied to different locations by simple research methods such as Nguyen Thi Hoang Lieu [17], Ho Chi Luan [18], Pham Hoang Khoi [19], Tran ThiDien Lam [20], Pham Cao Nghia [21]. Through the research studied, it can be seen that:

(1) Progress is an important aspect of any type of construction investment project. The relatedstudiestend to show that contractors are the subjects that have the most influence on the progress of construction investment projects with many effective factors.

(2) Causes affecting progress schedules can come from parties inside the project or from outside the project and will increase if the causes affecting the progress are not properly assessed. The main causes affecting the progress schedules of construction investment projects are recorded in Tables **2** and **3**.

(3) There has not been any research to thoroughly investigate the factors affecting the progress schedules of construction investment projects using public investment capital in Hanoi. The authors study the factors affecting progress schedules, not to rank the factors, but to find out how these factors affect progress schedules;

Table 2. Scale [22].

Value	AHP Scale (l, m, u)	Definition	Explanation
1	(1, 1, 1)	Equal influence	The influence of the two factors is the same
2	(1, 2, 3)	Between level 1 and level 3	
3	(2, 3, 4)	Moderate influential	The factor under consideration has a moderate influence compared to the rest of the factors.

(Table 2) contd.....

Value	AHP Scale (l, m, u)	Definition	Explanation
4	(3, 4, 5)	Between level 3 and level 5	
5	(4, 5, 6)	Quite influential	The factor under consideration is quite influential compared to the other factors.
6	(5, 6, 7)	Between level 5 and level 7	
7	(6, 7, 8)	Very influential	The factor under consideration is very influential compared to the other factors.
8	(7, 8, 9)	Between level 7 and level 9	
9	(8, 9, 9)	Extremely influential	The factor under consideration is extremely influential compared to the other factors.
$1/^{x}$	1/(x + 1), 1/x,1/(x -1)	AHP Scale-1	
$1/^{9}$	(1/9, 1/9, 1/8)		

(4) With the ability to solve problems without certain information, fuzzy set theory has the ability to describe progress schedules with fluctuations in the execution of construction projects. Sometimes fuzzy set theory helps to collect information on progress schedules more objectively.

2.2. F-AHP Method

F-AHP traditional method (Fuzzy Analytic Hierarchy Process) was developed from AHP (Analytical Hierarchy process) with the integration of fuzzy numbers to effectively deal with the fuzziness of data related to decision making. The F-AHP method has overcome some limitations of the traditional AHP method, so this method is increasingly used by many researchers in practice.

2.2.1. AHP Method

AHP method (Analytical Hierarchy process) is also known as hierarchical analysis. The AHP method is used to solve unstructured problems in economic, social and management science activities. The AHP methodology helps with complex multi-criteria decision-making problems. AHP enables decision makers to bring together the expertise of subject matter experts, combining objective and subjective data within a logical hierarchical framework. AHP helps to classify the relative priority for the options, and the problem occurs based on a scale. This scale is based on the judgment of the decision maker and the importance of those judgments, as well as the consistency in comparing alternatives in the decision-making process. AHP combines both qualitative and quantitative aspects of human thinking. Qualitative through hierarchical arrangement and quantitative through the result set of weights for each hierarchical factor. Three principles when implementing the AHP method: (1) Analyze the decision-making problem (build a hierarchical structure); (2) Comparative evaluation of components (pair comparison of factors); and (3) Aggregate priorities (determine weight matrices).

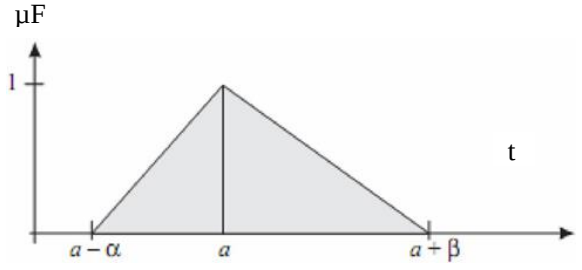

Fig. (1). Triangle fuzzy number [4, 15].

2.2.2. Fuzzy Set Theory

\The important feature of fuzzy set theory is that it proposes to use membership functions and then fuzzy operations to deal with “uncertain” or incomplete information, whose accuracy is only limited. Fuzzy concepts are shown to be very useful and easy to work with in the decision-aid problem [22 - 25]. A fuzzy set is a set whose boundaries are not clear or ambiguous. In a fuzzy set, the membership function is used to represent the membership level of an element. The membership function of a blurr set F over the sum set X denoted μF is determined by: μF: X->[0,1], where μF(t) is the degree of membership of the element t of the set X up a fuzzy set F. A fuzzy number is one whose membership function must satisfy the condition that it is continuous and convex. A fuzzy set is said to be normal if there exists a value 't' such that μF(t)=1. There are many different types of fuzzy numbers, but a triangular fuzzy number (fig. **1**) is often applied because of simple calculations and easy data processing.

$$\mu F(t) = \begin{cases} 1 - \frac{a-t}{\alpha} & \text{if } a - \alpha \le t \le a \\ 1 - \frac{a-t}{\beta} & \text{if } a \le t \le a+\beta \\ 0 \text{ for other cases} \end{cases} \quad \textbf{(1)}$$

In this research, the author uses the F-AHP method with triangular fuzzy numbers for the reason as follows:

- Experts' assessment of the causes affecting progress schedules for construction projects in Hanoi city using linguistic terms will reveal the nature of the problem rather than assigning them to values on a numerical scale. Linguistic phrases will be coded based on triangular fuzzy numbers to ensure objectivity in expert assessment.

- The causes affecting the progress of construction projects in Hanoi city are compared within a logical hierarchical framework. AHP helps to calculate the priority for each cause based on a scale.

- By using F-AHP to some extent, the relationship between the causes is taken into account. The weight of each cause is measured by the relationship of the pairs of causes to each other.

Objective of the paper is to rank and assess the causes affecting the implementation progress of construction projects using public investment capital in Hanoi city. The F-AHP

method is applied in the study to take advantages: (1) Rank causes affecting progress schedules based on the relative priority of the causes; (2) Ensure the objectivity of the expert's assessment.

3. RESEARCH METHODOLOGY

The steps to carry out the research are as follows:

- Step 1: Summarize and classify the causes affecting the progress schedules of construction projects in Hanoi city.

- Step 2: Build a hierarchical structure.

- Step 3: Set up the fuzzy pair comparison matrix.

- Step 4: Investigate and collect data.

- Step 5: Collect and process data.

- Step 6: Remove fuzzy parts.

- Step 7: Calculate the weight.

- Step 8: Check Data Consistency.

- Step 9: Conclusion.

(1) Summarize and classify the causes affecting progress schedules: The causes affecting the implementation progress of construction projects in Hanoi city are collected through reports and official websites of the Hanoi city's Department of Construction and the Ministry of Construction of Vietnam and synthesis through relevant studies. A group of 10 experts was assembled to name and categorize the causes uniformly. Criteria for selecting experts:

+ Currently, they are owners, contractors, and consultants who are participating in the implementation of a construction project using public investment capital in Hanoi.

+ At least seven years of experience working on construction projects in Hanoi city;

+ Have a university degree or higher;

+ Enthusiastic and willing to participate in answering the questionnaire.

The results of expert consultation were obtained for the following reasons, as in Table **3**.

Table 3. Value of random index (RI) [22].

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

CR coefficient of less than 10% is successful. If a CR > 10% indicates that the respondent's assessment is inconsistent, the data collection process should be repeated.

(2) Building hierarchical structure: The research problem is divided into three levels, including:

- Level 1: Research objectives are the causes affecting the progress schedules of construction projects in Hanoi city.

- Level 2: Grouping factors affecting progress schedules according to experts' opinion, including Group of causes related to investment capital, Group of causes related to NT, Group of causes related to phytoplankton, Group of other causes. Corresponding to the 2nd order cause will be the 1st order matrix.

- Level 3: Specific causes affecting progress. Corresponding to the 3rd degree causes will be the 2nd order matrices.

(3) Set up the fuzzy pair comparison matrix: The fuzzy pairwise comparison matrix is built based on survey data, but this result has been fuzzed according to the scale of Table **2**. In that scale, the fuzzy coefficient is automatic, taken by 1 according to Saaty's scale [22]. The notation for a fuzzy pair comparison matrix is J, which is made up of jij triangular fuzzy numbers as follows:

$$\bar{J} = \left(\bar{j}_{ij}\right)_{nxn} = \begin{bmatrix} \bar{j}_{11} & \bar{j}_{12} & \cdots & \bar{j}_{1n} \\ \bar{j}_{21} & \bar{j}_{22} & \cdots & \bar{j}_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \bar{j}_{n1} & \bar{j}_{n2} & \cdots & \bar{j}_{nn} \end{bmatrix} \quad \textbf{(2)}$$

(4) Surveys collect data: There are many ways to determine the survey sample size. To simplify the process while ensuring reliability, the authors use the method of determining the sample size according to Hair [23]. The ratio of observations on an analyte variable is 5:1, ensuring 95% confidence. After Step 1, 20 causes (Table **4**) were detected, corresponding to 20 observed variables. Thus, the minimum sample size = 20 * 5 = 100. Data collection method is a direct interview survey.

Table 4. Causes affecting progress schedules.

No	2nd Reason	3rd Reason		References
1	Owner (A1)	A11	Late payment from the owners to related parties upon completion of work	[4,5,9,13,15],
2		A12	Late decision-making from the owners when there are incidents or irregularities on the construction site	[4,9]
3		A13	Late handover from the owners of the construction site	[4,9,13,15]
4		A14	Late acceptance from the owners of completed work	[5,13,15]
5		A15	Late provision from the owners of documents to stakeholders or the documents provided are not as expected	[4,13,15]

(Table 4) contd.....

No	2nd Reason	3rd Reason		References
6	Contracts (A2)	A21	The capacity of the constractors, the ability to meet the resources of the constractors	[4,5,15,16,26,27]
7		A22	The construction schedule is not reasonable	[4 - 7,15,16]
8		A23	Management capacity of the construction unit, lack of experience in applying new technology in construction	[5,7,16,26,27]
9		A24	Major owner manages minor owner through a loose contract	[4,13]
10		A25	Inefficient use of construction equipment by the contractor	[4,8,15]
11		A26	Labor productivity of workers is lower than prescribed	[5,13,15]
12		A27	Change the source of supplies and materials to ensure the quality of the work	[7,13,28]
13		A28	There is no design of occupational safety measures in project construction	[8,13,16],
14	Consultants (A3)	A31	The details in the design documents are not clear or the design details are not suitable for the actual construction conditions.	[8,13,15,16]
15		A32	Poor management and expertise of supervisors	[5,7,15,16]
16		A33	The geological survey is sketchy and inaccurate	[8,9,15]
17	Others (A4)	A41	Adverse weather conditions	[8,9,15]
18		A42	There are no binding conditions in the contract to motivate contractors to complete the work early.	[5,7]
19		A43	Legal documents change over time	[4,13,15,28]
20		A44	Late delivery from the material supply facility unit	[4,7,15]

(5) Data collection and processing: Data processing is done with the support of Excel software. Expert opinions are blurred prior to synthesis. The matrix is created by triangular fuzzy numbers [13, 14]; the calculation of the sum of triangular fuzzy numbers is as follows:

$$\overline{J_{ij}} = (l_{ij}, m_{ij}, u_{ij});\ l_{ij} \leq m_{ij} \leq u_{ij};\ l_{ij}, m_{ij}, u_{ij} \in \left[\frac{1}{9}, 9\right]$$

$$\begin{aligned} l_{ij} &= \sqrt[n]{\prod_1^n l_{ijk}} \\ m_{ij} &= \sqrt[n]{\prod_1^n m_{ijk}} \\ u_{ij} &= \sqrt[n]{\prod_1^n u_{ijk}} \end{aligned} \quad \textbf{(3)}$$

(6) De-fuzzyfication: To return to the AHP pairwise comparison matrix and be computable, it is necessary to convert the fuzzy numbers (lij, mij, uij) into real numbers Jij. Deng [24] proposed to use the α-cut and λ index to indicate the level of confidence and attitude with the survey criteria. The α-cut index has a value from 0 to 1. The closer the α-cut index is to 1, the more confident the respondent is. λ has a value from 0 to 1, getting closer to 1 indicates optimism, getting closer to 0 indicates pessimism and 0.5 is normal. In this research, the author used α = 0.5 and λ = 0.5, showing that the respondents were in a normal state, and not too optimistic or pessimistic when participating in the discussion (ig. **2**). The fuzzification ends when the fuzzy numbers have been encoded through α and λ according to the following formulas:

$$J_\alpha = \begin{bmatrix} [j^\alpha_{11l}, j^\alpha_{11r}] & [j^\alpha_{12l}, j^\alpha_{12r}] & \cdots & [j^\alpha_{1ml}, j^\alpha_{1nr}] \\ [j^\alpha_{21l}, j^\alpha_{21r}] & [j^\alpha_{22l}, j^\alpha_{22r}] & \cdots & [j^\alpha_{2ml}, j^\alpha_{2mr}] \\ \cdots & \cdots & \cdots & \cdots \\ [j^\alpha_{n1l}, j^\alpha_{n1r}] & [j^\alpha_{n2l} \cdots, j^\alpha_{n2r}] & \cdots & [j^\alpha_{nml}, j^\alpha_{nmr}] \end{bmatrix} \quad \textbf{(4)}$$

$$J^\alpha_{ijl} = (m_{ij} - l_{ij}).\alpha + l_{ij}$$

$$J^\alpha_{ijr} = u_{ij} - (u_{ij} - r_{ij}).\alpha$$

$$j^\lambda_{ij\alpha} = \lambda . j^\alpha_{ijr} + (1 - \lambda).j^\alpha_{ijl}\ ;\ \lambda \in [0,1]$$

$$J^\lambda_\alpha = \begin{bmatrix} j^\lambda_{11\alpha} & j^\lambda_{12\alpha} & \cdots & j^\lambda_{1n\alpha} \\ j^\lambda_{21\alpha} & j^\lambda_{22\alpha} & \cdots & j^\lambda_{2n\alpha} \\ \cdots & \cdots & \cdots & \cdots \\ j^\lambda_{n1\alpha} & j^\lambda_{n2\alpha} & \cdots & j^\lambda_{nn\alpha} \end{bmatrix} \quad \textbf{(5)}$$

(7) Calculate the weight [22]: After deblurrication, the weight calculation is carried out according to the AHP method. The calculation steps are as follows:

- Step 1: Sum the columns.

- Step 2: Divide each value in the matrix by the sum of the column corresponding to that value, then sum the rows.

- Step 3: The calculated value is divided by the total number of criteria of the matrix which is the weight of the criteria to be found.

(8) Checking the consistency of data [22]: In the AHP pairwise comparison technique, it is necessary to consider the consistency of the data, or in other words, the consistency of the respondents' evaluations during the survey. This requirement is expressed through the most proportional CR. Determine the CR consistency ratio according to the formulas below:

$$CR = \frac{CI}{RI} \quad \textbf{(6)}$$

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \textbf{(7)}$$

In which: CI is the consistency index

N is the matrix size

λmax = Max (n)

RI is the random index. RI is a consistency index determined from a completely arbitrary matrix of randomly selected elements. By experimental method, Saaty determined the RI values (Table **3**) for the n-level comparison matrices.

CR is the consistency coefficient

(9) Conclusion: After the data is evaluated to be consistent, the new weights are calculated to ensure reliability to draw conclusions about the causes affecting the progress of construction projects in Hanoi.

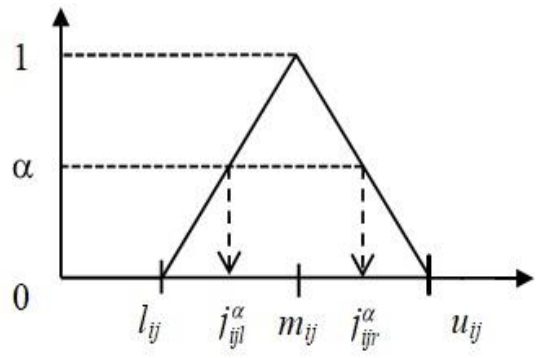

Fig. (2). α-cut index and triangle fuzzy number [22].

4. DATA ANALYSIS AND FINDING RESULTS

4.1. Causes Affecting Progress Schedules of Construction Projects Funded by State Capital in Hanoi City

The causes affecting the progress schedules of construction projects using public investment capital in Hanoi are summarized in Table **4**.

4.2. Survey Results

The survey on process schedules took place in Hanoi City between 2022-2023. After the direct investigation, the data obtained are as follows:

- Total number of surveys distributed: 235 surveys

- Total number of surveys collected: 215 surveys

- Total valid surveys: 205 surveys

Respondent Information:

- Regarding survey participants: Managers accounted for 31% of the votes; Technical staff accounted for 28% of the votes; Support officers and advisors accounted for 26% of the votes.

- Regarding work experience: respondents are mainly those with more than 7 years of work experience, accounting for the highest percentage (56%), those with 5-7 years of work experience accounting for 34%, those with experience from 3-5 years accounts for 10% and no respondents have less than 3 years of experience. The respondents, the majority of which have work experience equivalent to a certificate of type 2 or higher. This shows that the information collected from the survey is objective and has high practical value. With 205 valid votes, the author conducts data processing to prepare for the next analysis steps.

- About the project participants: accounted for 30.24% of the respondents working at the owner, 31.71% of the respondents were from consultants and 38.05% of the respondents were from the private sector contractors. The proportion of parties in the project participating in the survey is quite even, according to the original plan.

4.3. Data Analysis

(1) Level 1 matrix results comparing level 2 causes Level 1 matrix comparing level 2 causes includes 4 comparative criteria, which are 4 groups of causes that are A1, A2, A3 and A4.

- The result of level 1 matrix fuzzification is shown in Table **5**.

Result of level 1 matrix deblurrication is shown in Table **6**.

- Level 1 composite matrix is as Table **7**.

- Determination of CR rate is as Table **8**.

CR = 0,097 < 10% thus ensuring the consistency of the respondents' responses. Weights calculated for admitted grade 1 causes.

Table 5. The result of level 1 matrix fuzzification.

-	A1			A2			A3			A4		
A1	1,00	1,00	1,00	2,71	2,99	2,78	1,45	1,56	1,27	3,99	3,67	2,78
A2	0,36	0,33	0,37	1,00	1,00	1,00	1,90	1,90	2,78	3,80	3,89	3,67
A3	0,79	0,64	0,69	0,36	0,53	0,53	1,00	1,00	1,00	3,09	3,34	4,98
A4	0,36	0,27	0,25	0,27	0,26	0,26	0,20	0,30	0,32	1,00	1,00	1,00

Table 6. The result of level 1 matrix fuzzification.

-	A1		A2		A3		A4	
A1	1,00	1,00	2,85	2,89	1,51	1,42	3,83	3,23
A2	0,35	0,35	1,00	1,00	1,90	2,34	3,85	3,78
A3	0,71	0,66	0,43	0,53	1,00	1,00	3,22	4,16
A4	0,31	0,26	0,26	0,26	0,24	0,31	1,00	1,00

Table 7. The result of level 1 composite matrix fuzzification.

-	A1	A2	A3	A4	Weight
A1	1,00	2,87	1,46	3,53	**0,41**
A2	0,35	1,00	2,12	3,81	**0,3**
A3	0,68	0,47	1,00	3,69	**0,2**
A4	0,28	0,26	0,27	1,00	**0,1**

Table 8. Consistency rate results for matrix level 1.

Weighted Sum Value	Criteria Weights	Consistency Vector	Lamda Max	CI	RI	CR
1,830	0,412	4,438	4,258	0,086	0,890	0,097
1,210	0,280	4,316				
0,936	0,228	4,110				
0,332	0,080	4,168				

(2) The result of the corresponding level 2 matrix comparing the level 3 causes.

The corresponding level 2 matrix comparing level 3 causes includes matrices A1, A2, A3 and A4. Matrix A1 includes 5 comparison criteria: A11, A12, A13, A14 and A15.

- A1 matrix blur results is as Table **9**.
- Defuzzification Matrix A1 is shown in Table **10**.
- Composite Matrix A1 is as Table **11**.
- Determination of CR index is as Table **12**.

Table 9. The result of A1 matrix fuzzification (causes by the owner).

	A11			A12			A13			A14			A15		
A11	1,00	1,00	1,00	2,21	2,61	2,98	3,42	4,10	4,85	3,67	4,47	5,26	1,87	2,33	2,96
A12	0,34	0,38	0,45	1,00	1,00	1,00	2,14	2,52	3,09	1,49	1,57	1,72	0,97	1,38	1,59
A13	0,21	0,24	0,29	0,32	0,40	0,47	1,00	1,00	1,00	0,95	1,27	1,35	0,79	0,92	1,09
A14	0,19	0,22	0,27	0,58	0,64	0,67	0,74	0,79	1,05	1,00	1,00	1,00	0,90	0,93	1,57
A15	0,34	0,43	0,53	0,63	0,72	1,03	0,92	1,09	1,27	0,64	1,08	1,11	1,00	1,00	1,00

Table 10. The result of A1 matrix fuzzification (causes by project owners).

	A11		A12		A13		A14		A15	
A11	1,00	1,00	2,41	2,80	3,76	4,48	4,07	4,87	2,10	2,65
A12	0,36	0,41	1,00	1,00	2,33	2,81	1,53	1,65	1,18	1,49
A13	0,22	0,27	0,36	0,43	1,00	1,00	1,11	1,31	0,86	1,01
A14	0,21	0,25	0,61	0,65	0,76	0,90	1,00	1,00	0,92	1,25
A15	0,38	0,48	0,67	0,85	1,00	1,17	0,80	1,09	1,00	1,00

Table 11. The result of A1 matrix fuzzification (causes by project owners).

	A11	A12	A13	A14	A15	Weight
A11	1,00	2,60	4,12	4,47	2,37	**0,44**
A12	0,38	1,00	2,57	1,59	1,33	**0,20**
A13	0,24	0,39	1,00	1,21	0,93	**0,11**
A14	0,22	0,63	0,83	1,00	1,08	**0,11**
A15	0,42	0,75	1,08	0,92	1,00	**0,14**

Table 12. Result of A1 matrix consistency index (causes by project owners).

Weighted sum value	Criteria Weights	Consistency vector	Lamda max	CI	RI	CR
2,249	0,439	5,127	5,085	0,021	1,110	0,019
1,016	0,199	5,112				
0,561	0,111	5,064				
0,578	0,114	5,053				
0,697	0,137	5,069				

Table 13. The result of A2 matrix fuzzification (causes by project owners).

-	A21			A22			A23			A24		
A21	1,00	1,00	1,00	2,19	2,79	2,68	1,99	1,10	1,90	1,87	1,12	1,45
A22	0,37	0,36	0,46	1,00	1,00	1,00	3,78	4,88	3,78	1,58	1,59	1,58
A23	0,53	0,91	0,50	0,26	0,20	0,26	1,00	1,00	1,00	1,59	1,90	1,56
A24	0,69	0,89	0,53	0,63	0,63	0,63	0,64	0,53	0,63	1,00	1,00	1,00
A25	0,39	0,36	0,37	0,42	0,44	0,43	0,39	0,40	0,41	0,37	0,39	0,42
A26	0,39	0,43	0,34	0,37	0,36	0,39	0,26	0,27	0,30	0,37	0,44	0,34
A27	0,35	0,34	0,37	0,43	0,34	0,35	0,42	0,35	0,37	0,39	0,36	0,58
A28	0,26	0,26	0,28	0,41	0,42	0,29	0,40	0,40	0,42	0,27	0,29	0,30
-	A25			A26			A27			A28		
A21	2,67	2,78	2,56	2,97	2,34	2,59	2,67	2,98	2,89	3,56	3,79	3,89
A22	2,34	2,29	2,40	2,56	2,79	2,72	2,83	2,98	2,34	3,45	2,36	2,46
A23	2,46	2,49	2,56	3,34	3,69	3,92	2,67	2,87	2,39	2,36	2,47	2,51
A24	2,39	2,56	2,69	2,93	2,29	2,69	1,72	2,78	2,59	3,36	3,45	3,67
A25	1,00	1,00	1,00	2,93	2,82	2,29	3,29	4,70	5,00	2,98	2,13	2,39
A26	0,44	0,35	0,34	1,00	1,00	1,00	0,99	1,38	1,59	2,39	2,37	2,49
A27	0,20	0,21	1,01	0,63	0,72	1,01	1,00	1,00	1,00	2,39	0,40	0,55
A28	0,42	0,47	0,34	0,40	0,42	0,42	1,82	2,50	0,42	1,00	1,00	1,00

Table 14. A2 matrix blurrication results (causes by contractors).

-	A21		A22		A23		A24		A25		A26		A27		A28	
A21	1,00	1,00	2,49	2,74	1,55	1,50	1,50	1,29	2,73	2,67	2,66	2,47	2,83	2,94	3,68	3,84
A22	0,37	0,40	1,00	1,00	4,33	6,22	1,59	1,59	2,32	2,35	2,68	2,76	2,91	2,66	2,91	2,41
A23	0,67	0,65	0,16	0,23	1,00	1,00	1,75	1,73	2,48	2,53	3,52	3,81	2,77	2,63	2,42	2,49
A24	0,78	0,67	0,63	0,63	0,58	0,57	1,00	1,00	2,48	2,63	2,61	2,49	2,25	2,69	3,41	3,56
A25	0,37	0,37	0,43	0,43	0,40	0,40	0,38	0,40	1,00	1,00	2,88	2,56	4,00	4,85	2,56	2,26
A26	0,41	0,38	0,36	0,37	0,26	0,28	0,40	0,38	0,39	0,35	1,00	1,00	1,19	1,49	2,38	2,43
A27	0,34	0,35	0,38	0,34	0,38	0,36	0,37	0,44	0,21	0,25	0,67	0,84	1,00	1,00	1,40	0,48
A28	0,26	0,27	0,41	0,34	0,40	0,41	0,28	0,29	0,44	0,39	0,41	0,42	2,11	0,72	1,00	1,00

Table 15. Results of the A2 composite matrix (causes by the contractor).

-	A21	A22	A23	A24	A25	A26	A27	A28	Weight
A21	1,00	2,61	1,52	1,39	2,70	2,56	2,88	3,76	**0,22**
A22	0,38	1,00	5,28	1,59	2,33	2,72	2,78	2,66	**0,21**
A23	0,66	0,19	1,00	1,74	2,50	3,66	2,70	2,45	**0,15**
A24	0,72	0,63	0,58	1,00	2,55	2,55	2,47	3,48	**0,14**
A25	0,37	0,43	0,40	0,39	1,00	2,72	4,42	2,41	**0,11**
A26	0,39	0,37	0,27	0,39	0,37	1,00	1,34	2,41	**0,07**
A27	0,35	0,36	0,37	0,41	0,23	0,75	1,00	0,94	**0,05**
A28	0,27	0,38	0,41	0,29	0,42	0,42	1,07	1,00	**0,05**

Table 16. A2 matrix consistency coefficient results (contractor causes).

Weighted Sum Value	Criteria Weights	Consistency Vector	Lamda Max	CI	RI	CR
1,986	0,220	9,032	8,801	0,114	1,400	0,082
2,037	0,208	9,788				
1,356	0,155	8,764				
1,258	0,145	8,685				
0,915	0,109	8,428				
0,549	0,066	8,323				
0,436	0,051	8,604				
0,415	0,047	8,785				

CR = 0,019 < 10% thus ensuring the consistency of the respondents' responses. Weights calculated for owner-related causes are acknowledged.

(3) A2 matrix results

A2 matrix includes 8 comparison index: A21, A22, A23, A24, A25, A26, A27 and A28.

The result of A2 matrices fuzzification is shown Table **13**.

- A2 matrix fuzzification results is as Table **14**.

- A2 composite matrix is as Table **15**.

- Determination of CR index is shown in Table **16**.

CR = 0,082 < 10% thus ensuring the consistency of the respondents' responses. Weighted calculations for recognized contractor-related causes.

(4) A3 matrix results

A3 matrix includes 3 comparison indexes: A31, A32 and A33.

- A3 matrix fuzzification results is as Table **17**.

- A3 matrix fuzzification results is **18**.

- A3 composite matrix is as Table **19**.

- CR index determination is shown Table **20**.

CR = 0,066 < 10% thus ensuring the consistency of the respondents' responses. Weights calculated for causes related to the recognized consultant.

(5) A4 matrix results

A4 matrix includes 4 comparison index: A41, A42, A43 and A44.

- A4 matrix fuzzification results is as Table **21**.

- A4 matrix defuzzification results is as Table **22**.

- A4 composite matrix is as Table **23**.

- CRindex determination is shown in Table **24**.

Table 17. A3 matrix fuzzification results (causes by contractors).

-	A31			A32			A33		
A31	1,00	1,00	1,00	2,90	2,19	2,52	1,98	1,67	1,79
A32	0,40	0,46	0,34	1,00	1,00	1,00	1,87	1,45	1,56
A33	0,56	0,60	0,51	0,64	0,69	0,53	1,00	1,00	1,00

Table 18. A3 matrix fuzzification results (causes by contractors).

-	A31		A32		A33	
A31	1,00	1,00	2,55	2,36	1,83	1,73
A32	0,42	0,39	1,00	1,00	1,66	1,51
A33	0,58	0,55	0,66	0,60	1,00	1,00

Table 19. A3 composite matrix results (causes by the consultant).

-	A31	A32	A33	Weight
A31	1,00	2,45	1,78	**0,51**
A32	0,41	1,00	1,58	**0,27**
A33	0,56	0,63	1,00	**0,22**

Table 20. A3 composite matrix results (causes by the consultant).

Weighted Sum Value	Criteria Weights	Consistency Vector	Lamda Max	CI	RI	CR
1,567	0,505	3,103	3,068	0,034	0,520	0,066
0,831	0,272	3,059				
0,679	0,223	3,042				

Table 21. A4 matrix fuzzification results (other causes).

-	A41			A42			A43			A44		
A41	1,00	1,00	1,00	1,98	1,99	2,49	2,97	3,67	4,89	2,98	3,41	4,69
A42	0,40	0,50	0,51	1,00	1,00	1,00	1,79	2,98	2,49	1,79	2,70	2,50
A43	0,20	0,27	0,34	0,40	0,34	0,56	1,00	1,00	1,00	1,69	1,45	1,98
A44	0,21	0,29	0,34	0,40	0,37	0,56	0,51	0,69	0,59	1,00	1,00	1,00

Table 22. A4 matrix fuzzification results (other causes).

-	A41		A42		A43		A44	
A41	1,00	1,00	1,99	2,24	3,32	4,28	3,20	4,05
A42	0,45	0,50	1,00	1,00	2,39	2,74	2,25	2,60
A43	0,23	0,30	0,37	0,42	1,00	1,00	1,57	1,72
A44	0,25	0,31	0,38	0,45	0,58	0,64	1,00	1,00

Table 23. A3 composite matrix results (other causes).

-	A41	A42	A43	A44	Weight
A41	1,00	2,11	3,80	3,62	**0,5**
A42	0,47	1,00	2,56	2,42	**0,3**
A43	0,26	0,39	1,00	1,64	**0,1**
A44	0,28	0,41	0,61	1,00	**0,1**

Table 24. A4 matrix consistency index results (other causes).

Weighted Sum Value	Criteria Weights	Consistency Vector	Lamda Max	CI	RI	CR
1,969	0,483	4,081	4,053	0,018	0,890	0,020
1,113	0,273	4,081				
0,548	0,136	4,022				
0,437	0,109	4,029				

CR = 0,020 < 10% thus ensuring the consistency of the respondents' responses. Weights calculated for other causes are assumed.

5. ASSESS CAUSES AFFECTING PROGRESS SCHEDULES OF CONSTRUCTION PROJECTS FUNDED BY STATE BUDGET IN HANOI CITY

The results of level 1 weighting show that the group of causes related to project owners has the highest influence during the implementation of the construction project (Weight = 0.41). The second level of influence is the group of causes related to the contractor (weight = 0.28). Next is the group of causes related to the consultant (weight = 0.23). The group of other causes with the lowest weight of 0.08 shows the lowest level of influence among the 04 groups of causes considered (Fig. **3**). According to the opinions of survey participants, project owners always play a key role in decisions related to the implementation of construction projects using public investment capital in Hanoi. Owners hold capital and expand their role throughout the project implementation. This makes plans of progress schedules strongly influenced by owners in these construction investment projects.

Compared with the results from the conducted studies, it can be seen that the investor's budget plan has a great impact on the project implementation progress in construction projects using state capital. The results on the factor of weather conditions are also evaluated similarly to the conducted studies. However, the projects implemented in Hanoi show a difference: The factors which are caused by the contractor have a clear influence on the project implementation progress from

construction capacity, schedule planning, applying construction technology, managing construction, ensure the source of materials.

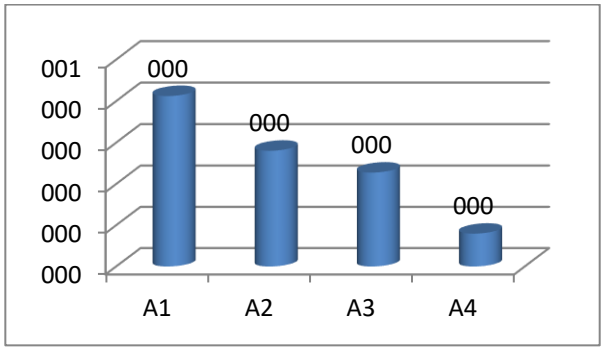

Fig. (3). Weight chart of cause groups.

5.1. Causes Related to Project Owners

Looking specifically at the causes related to the owner (Table **4**), it is found that the problem of late payment and slow decision-making when there is an unusual incident in the project are the causes that strongly affect the project schedule judgment. These causes have occurred in most of the current slow-moving projects and have become more serious in some projects such as CV1 Harmonized Lake Park project, PhungKhoang Lake Park project, construction project construction of an overpass at the intersection of Chua Boc-Pham Ngoc Thach, the project of building an overpass at the intersection of An Duong-ThanhNien road phase 2. In addition, factors such as the owner's delay in handing over the construction site, the owner's delay in taking over the completed work, and the owner's delay in providing documents to stakeholders also occurred and affected the progress for a period of time short time. There is no lasting effect on the total progress of the project. The weight of these causes has a lower score, respectively 0.11; 0.11; 0.14 (Table **25**). The reasons being considered are directly related to the owner's capacity and professionalism in the work. In the face of decision-making issues such as payment decisions, acceptance decisions for main construction tasks or construction phase transitions, decisions on serious construction site incidents, *etc*., the owner took a long time for consideration. This delay is causing great hindrance to other parties in the project and delaying the project implementation progress.

Construction project implementation phase is the most resource consuming stage. During the bidding process, contractors were required to have working capital for the project. Advance terms for projects using public investment capital are currently kept at 10-15%. With this advance, the contractor can smoothly implement the project's work. But the reality shows that contractors are heavily dependent on payment for completed works from owners. This reason leads to the late payment by the owner, which will make it difficult for the contractor to pay for the subcontractor, pay for labor and procure materials to prepare for the next work. In addition, accounting for over 80% of projects under medium-term capital, the owner's annual capital plan is approved by the subjective agency. The annual funding plan is often delayed due to many objective reasons from the governing body. This also slows down the solvency of the owner. The combination of reasons that caused the owner to delay payment to the project parties upon completion of the work has a high degree of influence on projects' progress schedules.

Table 25. The level of influence of the causes related to project owners.

No	Causes	Influence Weight
1	Late payment from the owner to related parties when completing the work	0,44
2	The owner makes a slow decision when there is an incident or reward on the construction site	0,20
3	Late to hand over the construction site from the owner	0,11
4	The owner is slow to take over the completed work	0,11
5	The owner provides documents late to the stakeholders or the documents provided are not as expected	0,14

Table 26. The level of influence of causes related to the contractor.

No	Causes	Influence Weight
1	The capacity of the contractors, the ability to meet the resources of the contractors	0,22
2	The construction schedule is not reasonable	0,21
3	Management capacity of the contractors, lack of experience in applying new technology in construction	0,15
4	Major contractors manage minor contractors through loose contract	0,14
5	Contractors use construction equipment inefficiently	0,11
6	Labor productivity of workers is lower than prescribed	0,07
7	Change the source of supplies and materials to ensure the quality of the work	0,05
8	There is no design of occupational safety measures in project construction	0,05

5.2. Causes Related to Contractors

Contractor-related causes (Table **5**) are more uniform than other groups. This does not represent low-impact contractor causes. It shows that the causes related to the contractor do have not much difference in the level of influence when

making a pairwise comparison between the causes. Therefore, contractors participating in the implementation of construction projects using public investment capital in Hanoi need to pay attention to all the reasons under consideration. It is necessary to pay attention to two issues: the contractor's capacity and project's appropriate construction schedule.

Regarding the construction schedule for the implementation of construction projects: The cause "Inappropriate construction schedule" has a higher weight of influence than other causes (Table **26**). According to the survey, participants, in projects using public investment capital, contractors in Hanoi have not paid attention to and properly assessed the role of the project's schedule. Before the contractor starts to implement the project, the contractor will submit the total progress to the supervision consultant, project management consultant and the owner for approval. After being approved, the total schedule is the basis for the parties in the project to have an appropriate arrangement of resources and capital. Also based on the total progress, the monthly schedule and the weekly schedule are detailed. However, these schedule plans are often prepared by a technical staff member who is not yet able to cover the project and understand the contractor's ability to provide resources. The timelines for each work item are set based on the subjective judgment of the scheduler. With short-term progress plans by week, by month, delays in implementation are better controlled, but they are far from the total approved progress schedule. The schedule plan does not take into account the downtime in construction and omitting this time leads to the delay in the progress of the whole project.

It should also be added that the schedule plan made by the contractor without the participation of the owner or the consultant leads to the plans of the parties in the project not matching the actual schedule currently building the project. When there is an adjustment or change in the contractor's progress, the other parties are passive and find it difficult to control their progress schedules.

About the contractor's capacity: Along with progress schedules, the contractor needs to have the right supply of resources. Feedback from the respondents said that over 80% of projects are having problems with providing resources that are not consistent with the project implementation schedule. Over 80% of the projects recorded from the survey occurred the situation of materials and materials arriving at the construction site massively but the workers were not ready to accept the job, the construction equipment was slow to be delivered to the construction site, or the condition of the materials was not ready. Material for a job lacks one type, excess of the other leads to insufficient construction conditions, The supply of human resources for the current projects is also a problem. Construction workers in Hanoi are generally assessed as hardworking people, but their compliance with the work plan is not good, and their work discipline is not appreciated. Construction workers in Hanoi and some neighboring provinces are highly dependent on foreign workers and are affected by the agricultural season. During the seasonal season (October-November crop, May-June crop), workers are difficult to find and often, have a serious reduction in the number of workers at construction sites in Hanoi. During off-season, idle labor is easier to attract for construction projects. A summary of construction sector reports [1 - 3] shows that in 2018, there were 176 projects that were delayed for a long time and 276 projects that had to be adjusted to the total schedule. In 2019, 68 projects were delayed for a long time and 394 projects had to adjust the total progress of construction projects. In 2020, there were 113 projects that were delayed for a long time and 82 projects had to adjust the total schedule.

Besides, the price of raw materials fluctuates unpredictably, directly affecting the construction of contractors. Many projects use public investment capital in the form of package contracts, leading to high risks for contractors. Faced with risks, some contractors choose to extend the schedule in the hope that the price of materials decreasing. This is also an issue that can be taken foreseen problem and needs to be resolved in public investment projects.

5.3. Causes Related to Consultants

Reviewing the causes related to the consultant found the cause from the design unit "Details in the design documents are not clear or the design details are not suitable with actual construction conditions" weighted more prominently than other causes (effect weight: 0.51) (Table **27**). This also reflects the reality of current Hanoi projects. Over 90% of projects are exposed to design risks at the level of cost and schedule interventions. Errors in the design are often discovered during construction, so they are not proactive in adjusting and approving the adjusted design. This result leads to the problem that design documents playing a very important role in construction projects in Hanoi. The selection of a design consultant should be carefully considered by the owner, and at the same time, strict verification and appraisal are carried out to minimize design risks, thereby avoiding negative impacts from design errors on projects' progress schedules. Reasons "Poor management and expertise in monitoring" and "Sketch and inaccurate geological survey" have lower weights, scores 0.27 and 0.22 (Table **27**), respectively.

Table 27. The level of influence of the causes related to consultants.

No	Causes	Influence Weight
1	The details in the design documents are not clear or the design details are not suitable with the actual construction conditions	0,51
2	Poor management and expertise of supervisors	0,27
3	The geological survey is sketchy and inaccurate	0,22

Table 28. The influence of other causes.

No	Causes	Influence Weight
1	Adverse weather conditions	0,5
2	There are no binding conditions in the contract to motivate contractors to complete the work early	0,3
3	Legal documents change over time	0,1
4	The material supply facility is slow to deliver	0,1

5.4. Other Causes

In the group of other causes, the cause "Unfortunate weather conditions" has a high weighted score (Table **28**). In recent years, climate change has been taking place globally. Hanoi is also affected by this situation. The laws of the weather change in an unusual and difficult to control direction. Flooding occurs when there is heavy rain and storms occur more often. The cause of flooding in Hanoi is analyzed largely because the water surface area and agricultural land area are gradually shrinking under the impact of rapid urbanization. In the period 2015 - 2020, the urban natural water surface area will decrease by 203.63 ha. Many ponds and lakes have been leveled to make land fund for urban development and technical infrastructure, the situation of people encroaching on water surface area for business and exploitation. This causes many difficulties for socio-economic development, as well as the construction sector in Hanoi. Low-base constructions are at risk of flooding, especially in the western part of Hanoi including rural areas located in green belts along river routes. From the survey, there are 5 projects that were forced to adjust the design during construction after considering the issues of climate change. Besides, progress plans in most construction investment projects in Hanoi must be adjusted more or less to adapt to climate conditions.

An issue that needs more attention in public investment projects in Hanoi is that the requirement to accelerate progress schedules is always ignored. The parties in the project are more interested in the project implementation process in accordance with the law than in promoting the project progress. The control of state management agencies through legal documents has not been synchronized and the general model has been inconsistent, which has indirectly affected the progress of construction projects. The binding of the parties on the schedule is not tight. In the contract, there is a term to complete the project, but the project progress is not specified in the contract. The regulations on rewards and penalties for delay are not mentioned or are not strong and it is difficult for the parties to handle the causes of delay.

6. DISCUSSION

There are 20 factors that affect the progress of the Hanoi construction project which uses the funded by State Budget. These are the main influencing factors during project implementation. Considering the aspects of project management content, the factors affect the progress cover all project management contents from quality, cost, design, and labor safety. The progress can be seen form the implementation framework for the project. Other management contents are established on the basis of the implementation schedule progress, and at the same time, they also affect the progress to change the approved schedule progress. This effect is complex and chain property. But it is very difficult to consider this interplay fully. In this study, the factors are considered under the assumption that they are independent. This is a limitation between research and practice.

The outstanding feature of the construction projects which use the state budget capital is that they are strongly inspired by the legal system on public investment, especially capital regulations. The results obtained clearly reflect this feature. It also makes a difference from construction projects using other capital sources. The related studies show that the contractor is the subject that causes a lot of influence on the project progress in terms of both the number of influencing factors and the degree of impact of the factors. However, the results are recorded the projects using state budget capital in Hanoi show that the contractor causes many impacting factors, but the owner causes higher influence. This also shows that the issue of capital is a very important factor, contributing significantly to the results of construction projects in Hanoi.

CONCLUSION

Based on projects ' progress schedules, the resources are mobilized, the parties work together to promote the development of the project. The pace of construction is going strong in Hanoi. However, the number of projects implemented behind schedule is increasing and serious. The author has investigated 20 reasons that affect the progress of the Hanoi construction project. The causes are classified into 04 groups. The results show that the groups of factors related to the project participants, namely owners, contractors, and sub-units, have a higher level of influence than other causes.

In order to improve progress schedules for construction projects in Hanoi city, there needs to be a drastic change in the project participants in which project parties need to pay more attention to the causes directly related to each actor. Project owners are interested and have a clearer plan on capital sources, and payment stages. Contractors build a reasonable schedule on the basis of calculating and providing resources for the project, and subcontractors carefully consider in design. At the same time, the project parties also need to recognize and actively respond to adverse weather conditions. The planning, especially the outdoor construction works, must be calculated according to the weather rules of the Northern Vietnam and the weather forecast to make reasonable adjustments.

The project implementation phase is a stage that requires the participation of many parties and consumes a lot of resources. This is a complicated process. The progress considerations should be placed in each relationship with the requirements of quality, cost, contractor's ability to provide resources, ability to meet capital, and risk. In the study, the

factors which affect the progress are considered assuming they are independent of each other. The obtained results are a useful but incomplete reference for the project managers who consider the management solutions suitable.

An extended study should be done of all other project phases, such as project preparation phase, project operation phase. This is carried out to assess better of causes affecting progress schedules on construction investment projects funded by the state budget in Hanoi City.

CONSENT FOR PUBLICATION

Not applicable.

AVAİLABİLİTY OF DATA AND MATERİALS

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CONFLICT OF INTEREST

The author declares no conflict of interest financial or otherwise.

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REFERENCES

[1] "Hanoi Planning and Investment Department, Report on assessment and supervision of overall investment in Hanoi in 2018, no 137/BC-KH&ĐT", 2019.

[2] "Hanoi Planning and Investment Department, Report on assessment and supervision of overall investment in Hanoi in 2019, no 83/BC-KH&ĐT", 2020.

[3] "Hanoi Planning and Investment Department, Report on assessment and supervision of overall investment in Hanoi in 2020, no 79/BC-KH&ĐT", 2021.

[4] J. Vijayalaxmi, "Chapter 29 - Assessment of factors affecting time and cost overruns in construction projects", In: *Risk, Reliability and Sustainable Remediation in the Field of Civil and Environmental Engineering.,* Elsevier, 2022, pp. 511-521.

[5] S. Mohamed, and AnasChafi, "Empirical research of schedule delay in Moroccan construction projects", *Int. J. Cons. Manag.,* vol. 20, no. 7, pp. 783-800, 2020.

[6] J-B. Yang, and S-F. Ou, "Using structural equation modeling to analyze relationships among key causes of delay in construction", *Can. J. Civ. Eng.,* vol. 4, no. 4, pp. 321-332, 2008. [http://dx.doi.org/10.1139/L07-101]

[7] A.H. Memon, and I.A. Rahman, "Factors affecting construction cost in mara large construction project: Perspective of project management consultant", *Int. J. Sustainable Cons. Eng. Technol.,* vol. 1, no. 2, 2010.

[8] F. Remon, "Exploring delay causes of road construction projects in Egypt, Alexandria", *Eng. J.,* vol. 55, no. 2, pp. 1515-1539, 2016. [http://dx.doi.org/10.1016/j.aej.2016.03.006]

[9] I. Mahamid, "Analysis of schedule deviations in road construction projects and the effects of project physical characteristics", *J. Financial Manag. Prop. Constr.,* vol. 22, no. 2, pp. 192-210, 2017. [http://dx.doi.org/10.1108/JFMPC-07-2016-0031]

[10] C.S. McCahon, "Using PERT as an approximation of blurr project-network analysis", *IEEE Trans. Eng. Manag.,* vol. 40, no. 2, pp. 146-153, 1993. [http://dx.doi.org/10.1109/17.277406]

[11] O Ökmen, and A Öztaş, "A CPM-based scheduling method for construction projects with fuzzy sets and fuzzy operations", *J. S. Afr. Inst. Civ. Eng.,* vol. 56, vol. 2, pp. 2-8, 2014.

[12] S. Chanas, and P. Zielinski, "Critical path analysis in the network with blurr activity times", *Blurr Sets Sys.,* vol. 122, no. 2, pp. 195-204, 2001. [http://dx.doi.org/10.1016/S0165-0114(00)00076-2]

[13] Truong Cong Bang, "Using blurr sets in making progress of construction investment projects", *Cons. Magaz.,* vol. 7, pp. 136-140, 2021.

[14] Doan Tu Dinh, *"Managing the construction plan of a new urban area project in Vietnam"*, Doctorate thesis, Hanoi Architectural University, 2020.

[15] L.H. Tai, "Investigating factors affecting Construction Cost and Schedule Overruns of public investment projects", *Tran Van Thong and Dang Cong Thuat,* 2022.

[16] T.H. Tuan, "Factors acffecting cost and time of project completion in construction phase: A case study in Can Tho city", *Can Tho Uni. J. Sci.,* vol. 30, pp. 26-33, 2014.

[17] H.L. Nguyen Thi, *"Factors affecting the completion progress of technical infrastructure construction projects in Ho Chi Minh City"*, Master thesis, University of Economics Ho Chi Minh City, 2019.

[18] L. Ho Chi, *"Factors affecting the completion of construction projects using state budget capital in Ca Mau province"*, Master thesis, University of Economics Ho Chi Minh City, 2018.

[19] K. Pham Hoang, *"Factors affecting the completion progress of public investment projects in Vinh Long province"*, Master thesis, University of Economics Ho Chi Minh City, 2023.

[20] D.L. Tran Thi, *"Factors affecting the delay in progress, exceeding the estimates of projects using state budget capital in Dong Thap province"*, Master Thesis, City University of Economics Ho Chi Minh City, 2019.

[21] N. Pham Cao, *"Analysis of factors affecting the construction progress of high-rise buildings applied to The Soir Garden building project"*, Master thesis, ThuyLoi University, 2015.

[22] T.L. Saaty, "The analytic hierarchy process – What it is and how it is used", *Math. Model.,* vol. 9, no. 3–5, pp. 161-176, 1987. [http://dx.doi.org/10.1016/0270-0255(87)90473-8]

[23] *Multivariate Data Analysis,* Pearson: New Jersey, 2014.

[24] H. Deng, "Multicriteria analysis with fuzzy pairwise comparison", *Int. J. Approx. Reason.,* vol. 21, no. 3, pp. 215-231, 1999. [http://dx.doi.org/10.1016/S0888-613X(99)00025-0]

[25] H. Prade, "Using fuzzy set theory in a scheduling problem: A case study", *Fuzzy Sets Syst.,* vol. 2, no. 2, pp. 153-165, 1979. [http://dx.doi.org/10.1016/0165-0114(79)90022-8]

[26] "Hanoi accelerates disbursement of public investment capital", Available from:http://tayho.hanoi.gov.vn/kinh-te-chinh-tri/-/view_content/7540507-ha-noi-day-nhanh-tien-do-giai-ngan-von-dau-tu-cong.html

[27] National Assemble, "Law on public investment", Available from:https://fsppm.fulbright.edu.vn/cache/MPP7-541-R9.3E-Law%20on%20Public%20Investment%202014--The%20National%20Assembly-2015-01-07-11214028.pdf

[28] "Clearly identify the shortcomings and difficulties to solve and promote public investment in 2023", Available from:https://kinhtevadubao.vn/nhan-dien-ro-cac-ton-tai-kho-khan-de-thao-go-thuc-day-dau-tu-cong-nam-2023-25307.html