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The Influence of External Factors on Construction Project Performance Based on Estimated Duration in Jakarta

Abstract

Estimation of project duration needs to be precise to support performance as a success factor. Obstacles occur when estimation is conducted in an environment with less precedent data or standardization. Although this is a common problem in developing countries, it decreases project performance due to the less precise estimation. Therefore, this research proposes the use of statistical external data as an alternative solution in developing indicators of a country. Statistical data is provided by Country Statistical Bureau, World Bank, or World Economic Forum. This research examines the correlation between identified dominant external as independent factors and duration prediction of ongoing construction projects in Jakarta, Indonesia as the dependent factor, which calculated using the Earned Schedule method. A multivariate factor analysis method was conducted to identify dominant factors, and multivariate linear regression analysis was performed between duration prediction and dominant factors. Furthermore, the study added the floor numbers and area to accommodate the building characteristic and using the determinant coefficient Goodness of Fit (R^2) as sensibility benchmarks. The results show that the determination value (R^2) is 76.3%, meaning that external factors and duration prediction have a good correlation.

Keywords – influence external factors, duration prediction, Earned Schedule method, factor analysis, multivariate analysis.

Introduction

Construction is a temporary activity within a certain period with resource allocation to produce products whose quality criteria have been clearly stated. To achieve the final goal of the project, some requirements have to be fulfiled, such as the allocated cost (budget), duration (scheduling), and quality. These three related indicators are important parameters for project organizers (Watt, 2014). Moreover, meeting these requirements calls for an application of management in knowledge, skills, tools, and techniques to project activities (Project Management Institute, 2017). One way to managing a project is balancing the scope, quality, schedule, budget, resources, and risks. The relationship of these factors is such that when any of these changes, at least one other is affected.

Government policies help the construction sector and its elements contribute towards a country's development. The average contribution of this sector to development, especially in developing countries, such as Indonesia, is shown in Figure 1. According to the World Bank, the construction sector contributes to the growth of a country by at least 12% or more (World Bank, 1984). Figure 1 shows that several developing ASEAN countries still contribute below the average, with only Singapore and Malaysia reaching over 12%. Moreover, Indonesia is only at around 10.71%, less competitive than the other developing countries it represents. Therefore, there is a need for a development model of duration estimation to enhance project performance in developing countries. This would increase the accuracy, performance, profits, and competitiveness (Porter, 1994) of their construction industry.

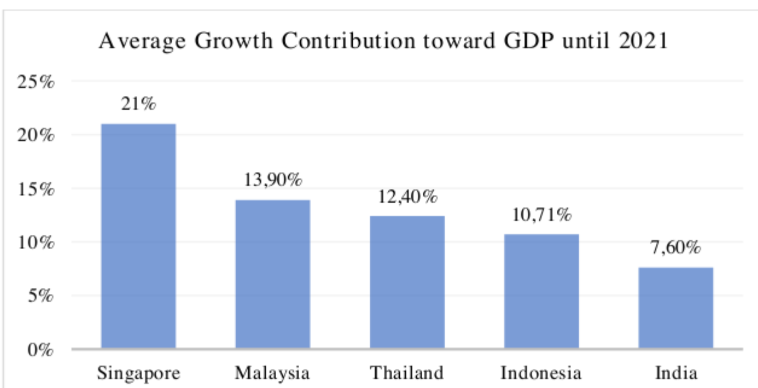

Figure 1. Construction Sector Contribution Towards Gross Domestic Product (GDP) in Several Developing Countries Chart (Source: Official statistic record from each countries)

The construction of high-rise buildings in developing countries commonly takes place in capital cities, such as Jakarta, Indonesia. Data from The Skyscraper Center 2020 shows that Jakarta city has the largest number of high-rise buildings in Indonesia (Council on Tall Buildings and Urban Habitat, 2020), representing the country for high-rise building construction project performance.

The performance duration estimation data of some building projects in Jakarta reflect the deviation in accuracy. The more completion time increase, the more the deviation becomes greater (Basuki, 2018). Additionally, it was found that delay occurred in most projects, indicating a poor accuracy rate between the predicted and actual duration.

This prediction inaccuracy and delays could be caused by several internal and external factors affecting the construction project performance. Some factors could be caused by the same reason or one element that triggers the impact in other factors (Porter, 1994). Furthermore, several factors could appear unexpectedly and immediately, directly affecting the entire continuity of project activities. For instance, this could happen when stakeholders ignore the factors with a potential effect on project duration, affecting performance. Previous studies showed that external factors should be considered in the continuity and sustainability of project performance, especially regarding the accuracy of construction duration. Arif et al. (2015) stated that every construction work is unique, meaning that there are many differences among various projects, such as in cost or time. Therefore, the accuracy of these indicators is essential in measuring the project team, performance, and overall success. Maqsoom et al. (2019) found that it is difficult to deal with the delay in construction firms due to the relationship between the influence factors, firm size, and experience. Moreover, Khoshgoftar et al. (2010) stated that, according to the Office for Supervision and Evaluation of Designs (2006), Iranian construction projects experienced a delay of about 30%, 74.5%, and 75% in 2001, 2002 and 2003, respectively. Therefore, a delay is a serious problem in Iranian construction projects that could be accepted as a habit in case no concrete preventive steps are taken. Several factors were found to cause the delay in the construction project.

An accurate prediction of project duration at the planning stage is an important part of the construction management. Also, project performance must be as best as possible to facilitate efficient project management and the maximum realization of the final goals. This could be accomplished by observing the influence factors that could directly or indirectly affect project performance. This research identifies dominant country development statistical external factors influencing project performance. It focuses on its correlation toward predicted duration of the construction project that have been validated through actual duration. This is due to the need for an alternative duration prediction in developing countries with low productivity standards. Furthermore, these countries may lack precedent experience in high-rise buildings. Therefore, this study uses external factors data that could be found from the Central Bureau of Statistics, World Bank, and World Economic Forum.

The structure of the paper of this research is described as follows. First, Introduction section will explain about the contribution of construction industry to a country. In spite of its importance and essentiality, still there are a lot of inappropriateness in three main dimension of project performance, especially in schedule delay, that caused by external factors that can show up immediately in the middle of project execution. Second, several studies about the importance of external factor influences to the project performance will be reviewed in Literature Review section. Also, a review about Earned

Schedule will be carried out in this section. Third, Research Methodology section will show the steps to conduct this whole research and Result and Discussion section will show its process and result, including the explanation of filtering the external factors by looking for their availability in data resource, questionnaire distribution, validation and reliability test to see the validity, feasibility, and accuracy of collected data, predicted duration calculation, and Goodness of Fit (R2) calculation using multivariate regression analysis. Last, the conclusion will be concluded based on the result of analysis in the Conclusion section.

Literature Review

The Influence of External Factors

The concept of project performance that is expected in a construction project is in the form of the lowest possible cost, on time, quality as expected, which are influenced by several factors both directly and indirectly. In this study, internal factors are those directly connected to the construction process, such as cost, quality, and project execution time. External factors affect the construction process but are not directly connected, such as environment, and political and economic condition, as the indicators of a country's development. This data is usually found in the Central Bureau of Statistics (CBS), World Bank (WB), or published in World Economic Forum (WEF) which is available for almost all country in the world.

Some previous studies found many factors that directly or indirectly influence the sustainability and success of construction projects in various regions. For instance, Arif et al. (2015) found that labor rates and productivity vitally influence accuracy. Hwang & Lim (2013) stated that success factors support and measure the success of project implementation. In line with this, Kog & Loh (2012) identified three latent variables that could affect project success, including Economic Factors, Human Resources, and Technology. Many previous studies identified the problems affecting the company's performance and the overall country's economy. For instance, "Causes of Delays in Iranian Construction Projects" by Khoshgoftar et al. (2010) stated financial factors could obstruct the performance of the project in Iran. Financial constraints by the owner during the construction phase could lead to problems for contractors, such as paying workers, employees, subcontractors, and rent for machinery and equipment, and purchasing the needed materials. Khoshgoftar et al. (2010) distributed questionnaires to government contractors, consultants, and owners to determine the factors influencing projects in Iran. Nine other factors found are problems due to improper planning in simultaneously designing and executing the project, and excessive workloads for site and project managers, making them unable to carry out their duties properly. Moreover, other problems involve contract management, including incomplete plans and drawings, and unpredictable tasks and works of several items. Other problems are lack of communication between the parties, subcontractor strikes because of late payment, and equipment failure. Additionally, other factors are earlier and late material delivery that causes cash flow problems, inadequate contractor experience, and change orders. Panas & Pantouvakis (2018) in "On the Use of Learning Curve for The Estimation of Construction Productivity" connected the worker performance coefficient through the learning curve of specific repetitive activities. This is because worker capability significantly affects project success. Therefore, worker ability and productivity could be increased by developing experience in construction (Gong et al., 2011).

El-Gohary & Aziz (2014) stated that productivity in the construction industry could be formulated in many ways. Based on Hwang & Lim (2013), productivity is strongly influenced by Economic, Human Resource, and Technology factors, which will be three base variables in this research.

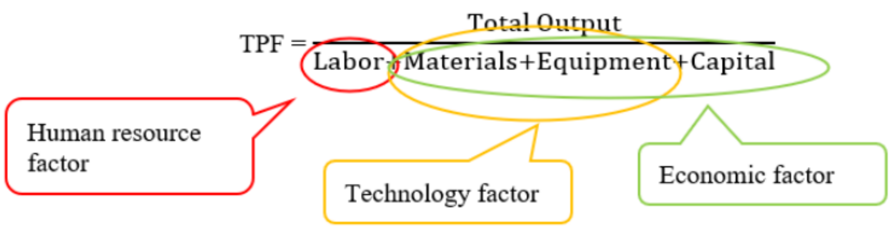

Figure 2. Representation of Total Production Factor (TPF) (Source: Hwang & Lim, 2013)

(1) Economic Factor

Many studies have identified this problem as a factor affecting construction productivity and impact the firm's performance and the country's overall economy (El-Gohary & Aziz, 2014). Furthermore, economic factors influence the construction duration (Hoffman et al., 2007). Another research shows that managerial effectivity rate is an influence that reduces project duration (Chan et al., 2004).

By selecting economic factors through availability filtering of statistical data on either Central Bureau of Statistics (CBS), World Bank (WB), or World Economic Forum (WEF), several variables are chosen (Basuki, 2018), including:

(i) Exchange Rate
(ii) Interest Rate index
(iii) Inflation
(iv) Gross Domestic Product
(v) Material Price index

(2) Human Resource Factor

Construction requires intensive labor, whose productivity is essential for most projects' profitability. Many studies have identified this problem as a factor affecting construction productivity, impacting the performance of firms and the country's overall economy (El-Gohary & Aziz, 2014).

Construction labor productivity is a widely researched topic. In most countries, labor costs comprise 30 to 50% of the total project expenditure and are considered a true reflection of the operation's economic success (Jarkas & Bitar, 2012). Therefore, this research identifies and assesses the relative importance of factors influencing labor productivity.

Human resource factors were selected through availability filtering of statistical data on either CBS, WB, or WEF, several variables are chosen (Basuki, 2018), including:

(i) Education Level index
(ii) Labor Experience index
(iii) Labor Availability index
(iv) Health Level index

(3) Technology Factor

Porter (1994) in the book "The Competitive Advantage of Nations" stated that a company that gains a competitive advantage in its industry has a prior initiative and is aggressively developing a new market and technology. The success of the company in an industrial sector indirectly affects the growth and development of its country. Therefore, the technology factor is an important input for analysis in this research because it represents science and is highly affected by education level.

By selecting technology factors through availability filtering of statistical data on either CBS, WB, or WEF, several variables are chosen (Basuki, 2018), including:

(i) Innovation index
(ii) Technology Absorption index
(iii) New Technology Availability index

Earned Schedule (ES)

One way of predicting the final duration of construction projects is using the Earned Schedule (ES) method, which developed from Earned Value Management (EVM) by Walter Lipke in 2003 and still continues to develop. The ES method provides more reliable results in estimating the final project duration (Lipke et al., 2009).

The Earned Schedule (ES) method determines the location of the actual development time (EV curve) against the plan that should have occurred (PV curve). This is performed by plotting the EV curve in actual time to the PV curve (Figure 3). The projection point obtained from the plotting results is the ES value.

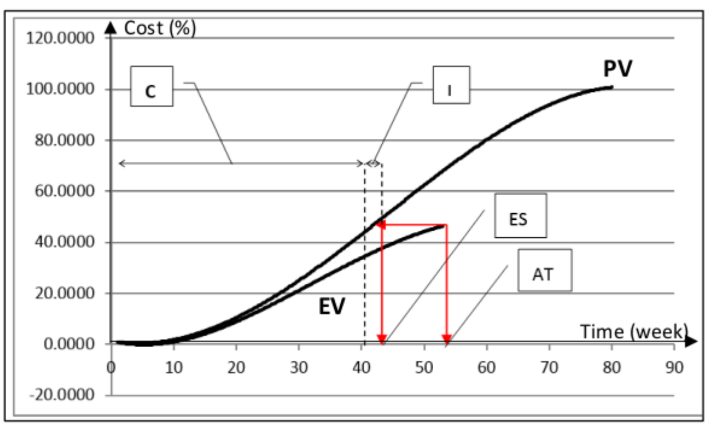

Figure 3 The concept of Earned Schedule (Source: Basuki, 2018)

Based on Lipke et al. (2009), the two main components in this method are C and I value. C is the period value determined by counting the additional time of the

Performance Measurement Baseline (PMB) that fulfils the condition $EV \geq PV$. Similarly, I is a value from the result of linear interpolation to determine PMB value at a certain point. The I component of ES only involves adding the final time of the computation. The obtained PMB curve is created from cumulative value of PV at periodic time interval and it is not a defined mathematical function, thus interpolation is required to determine the fractional part of the final increment to claim as complete (Lipke et al., 2009). The I component could be calculated by the equation (1):

$$I = (EV - PV_C) / (PV_{C+1} - PV_C) \quad (1)$$

Where EV is Earned Value (obtained from the completion of work for a certain period), while PV_C is Planned Value on a certain observed point (Cost budget al.located based on the work schedule for a period). PV_{C+1} is the Planned Value on another observed point after the previous one. Furthermore, the ES value is calculated as follows in equation (2):

$$ES = C + I \quad (2)$$

Based on Project Management Institute (2011) Practice Standard for Earned Value Management in Kim & Kim (2014), Earned Schedule provides two indicators of time-based schedule performance. These are Schedule Variance (SV) and Schedule Performance Index (SPI). In this case, SV shows the lateness to the original schedule, while, SPI indicates the efficiency of the time spent. Furthermore, an SPI ratio with a value less than 1 indicates that the project would be completed later than the original plan. The SV indicator is calculated as follows in equation (3) and SPI indicator in equation (4), where AT is Actual Time from the observed project's duration.

$$SV = ES - AT \quad (3)$$

$$SPI = \frac{ES}{AT} \quad (4)$$

The value from the indicator produces data useful in estimating the end duration of the project, known as Estimate at Completion (EAC). It is calculated as follows in equation (5), where PD is the Planned Duration of a construction project from start to finish.

$$EAC = AT + \frac{PD - ES}{SPI(t)} \quad (5)$$

Scheduling using the ES method shows the work progress consistency relative to the initial plan. While the EV method uses a cost-based indicator, ES measures time-based performance and is considered more stable than a cost-based indicator. Additionally, ES eliminates the disadvantages of SPI in the EV method. This implies the value of 1 as the project nears completion even when falling behind or ahead of the schedule. Therefore, the ES concept introduces a new time-based SPI that is more reliable than the EV method (Narbaev & Marco, 2014). Also, this method could also find out the performance of the estimator through the ongoing projects. Furthermore, it is simpler when the prediction of project completion duration is calculated with a time-based indicator (Henderson, 2005).

Research Methodology

This research is a quantitative research using linear regression analysis conducted from 2017 to early 2020 before COVID-19 pandemic happened and focused on identifying external influence factors by literature study and searching for the relationship between them and predicted duration of construction projects.

The structure of this research is conducted by four steps. First, the literature study was conducted to identified external factors that influence the construction projects. Several external factors are then obtained by filtering the availability of data in Central Bureau of Statistics (CBS), World Bank (WB), and World Economic Forum (WEF). This also include the reviews for Earned Schedule (ES) as the duration prediction calculation method that will be used in this research. Second, the several external factors that have been filtered are arranged in a questionnaire to be distributed to respondents to see how much influenced they have in practical field. The duration prediction also could be calculated using ES method since it has no correlation at all to the external factors until this step. Third, validation test and reliability test need to be done to see the validity, feasibility and accuracy of questionnaire data that has been collected. The external factors data are then filtered by Factor Analysis method to obtained several factors which have a strong relationship between variables and factors. Fourth, the multivariate regression analysis is conducted to see how strong the correlation between identified external factors and duration prediction. The correlation will determine whether the external factors affect the duration prediction calculation or it has no effect at all. The results are expected to contribute to the estimation duration process in an environment with less precedent and productivity data to ensure accurate and reliable estimation.

External Influence Factors Identification

This study used external factors because developing countries lack a productivity standard or building project precedent. Therefore, it was impossible to estimate the cost or duration. However, external factors from the Central Bureau of Statistics (CBS), World

Bank (WB), and World Economic Forum (WEF) data are expected to help in the estimation process. A meta-analysis approach with source literature from journals and textbooks as references is conducted in previous study (Basuki, 2018). A literature study was first conducted from 25 sources on the external factors influencing construction project performance. About 37 influential external factors were identified and distributed into Economic, Human Resource, and Technology variables based on Hwang & Lim (2013) and Porter (1994) as shown by Table 1a.

Table 1a External factors distribution according to latent variables

Year	Indicator Identification	Variable	n
1998	Inflation (Akinci & Fischer, 1998)	E	1
2004	Economic environment (Chan et al., 2004)	E	2
2009	Escalation of material prices (Enshassi et al., 2009)	E	3
2009	Effect of inflation (Shane et al., 2009)	E	4
2010	Growth Domestic Product (GDP) growth (Lucko, 2010)	E	5
2012	Material prices (Astina et al., 2012)	E	6
2013	Inflation (Alhomidan, 2013)	E	7
2013	Exchange rate fluctuation (Alhomidan, 2013)	E	8
2013	Changing of banker policy for loans (Alhomidan, 2013)	E	9
2013	Price fluctuation (Azis, 2013)	E	10
2014	Inflation rate (Akanni et al., 2014)	E	11
2014	Unexpected prices raise for material (Akanni et al., 2014)	E	12
2014	Foreign exchange rate (Akanni et al., 2014)	E	13
2014	Economic and financial (Akanni et al., 2014)	E	14
2015	Gross Domestic Product (Basuki & Soelaiman, 2015)	E	15
2015	Level of interest rates (Basuki & Soelaiman, 2015)	E	16
2015	Exchange rate (Basuki & Soelaiman, 2015)	E	17

2015	Stable macro-economic environment (Musa et al., 2015)	E	18
2015	Low interest rate (Musa et al., 2015)	E	19
1995	Labor (Chan et al., 2004)	HR	1
2004	Human related factors (Chan et al., 2004)	HR	2
2006	Worker (Sukumaran et al., 2006)	HR	3
2007	Health and safety regulation (Lientz & Rea, 2007)	HR	4
2007	Labor (Sambasivan & Soon, 2007)	HR	5
2009	Labor experience (Dai et al., 2009)	HR	6
2009	Education (Dai et al., 2009)	HR	7
2011	Labor and morale (Rivas et al., 2011)	HR	8
2012	Labor skill (Astina et al., 2012)	HR	9
2012	Foreman or operator lack of ability to operate the equipment (Astina et al., 2012)	HR	10
2012	Insufficient number of workers (Astina, 2012)	HR	11
2012	Level of skilled labor required (Kog & Loh, 2012)	HR	12
2012	Labor productivity (Jarkas & Bitar, 2012)	HR	13
2013	Shortage of labor (Azis, 2013)	HR	14
2013	Unqualified/inadequate experienced labor (Azis, 2013)	HR	15
2014	Shortage of labor (Akanni, 2014)	HR	16
2014	Labor experience and skill (El-Gohary & Aziz, 2014)	HR	17
2015	Index of education degree (Basuki & Soelaiman, 2015)	HR	18
2015	Index level of labor supply (Basuki & Soelaiman, 2015)	HR	19
2015	Index level of human health (Basuki & Soelaiman, 2015)	HR	20
2007	Gaps in current technology (Lientz & Rea, 2007)	T	1
2007	Equipment (Sambasivan & Soon, 2007)	T	2
2012	Verification of the role of technology accuracy (Sepasgozar & Bernold, 2013)	T	3
2013	Inadequate modern equipment (Asiz, 2013)	T	4
2013	Slow mobilization of equipment (Asiz, 2013)	T	5

2013	Software development (Zhou et al., 2013)	T	6
2014	Construction Technology and Resources (Akanni et al., 2014)	T	7
2015	Technology usage (Basuki & Soelaiman, 2015)	T	8

From these 37 influential external factors, 12 measured external factors are identified by filtering through the data available at official statistic sources, including the Central Bureau of Statistics (CBS), World Bank (WB), and World Economic Forum (WEF). Table 1b shows the 12 external factors which are then used for the preparation of the questionnaire, where En, HRn, and Tn are Economic factor, Human Resources factor, and Technology factor that were identified from literature n respectively.

Table 1b Distributed Table 1a into Availability of Measured Indicator

No	Identification of Literature Variables	Indicator	CBS	WB	WEF
1	E1, E2, E4, E7, E11, E14, E18	Inflation	√	√	√
2	E2, E3, E6, E10, E12	Material Price index	√	√	√
3	E5, E14, E15, E18	Gross Domestic Product	√	√	√
4	E8, E9, E13, E16, E19	Exchange Rate	√	√	√
5	E8, E9, E13, E17	Interest Rate index	√	√	√
6	HR1, HR2, HR3, HR8, HR11, HR13, HR14, HR16	Labor Availability index	√	√	√
7	HR2, HR6, HR9, HR12, HR15, HR17	Labor Experience index	√	√	√
8	HR2, HR7, HR18	Education Level index	√	√	√
9	HR2, HR4, HR20	Health Level index	√	√	√
10	T1, T2, T3, T4, T5, T13	New Technology Availability index			√
11	T6, T8, T9, T10, T13,	Technology Absorption index		√	√
12	T6, T7, T11, T12	Innovation index			√

The selected external factors were then used as materials to arrange and develop the questionnaires to be distributed to stakeholder respondents about predicting construction project duration. The questionnaires used Likert 1 - 5 scale answer options according to the project duration, where 1, 2, 3, 4, and 5 indicate a very unaffected relationship, slightly affected, moderately affected, very affected, and extremely affected respectively. Since the questionnaire had no direct correlation to duration estimation, the respondents were selected based on sufficient experience and insight. This means that the questionnaires were distributed to the random person who usually conduct and responsible the prediction duration, which are project managers or site engineers that handle the scheduling in the construction project in Jakarta.

After collecting the returned questionnaire answers, Factor Analysis Method was conducted to reduce the number of variables for practical purposes. Additionally, the method was used to determine the dominant variables to be used in analysing the influence of external factors.

The dominant external factors were determined using Factor Analysis Method starting with validation and reliability tests. The Measure of Sampling Adequacy (MSA) was then performed, followed by Rotated Component Matrix to reduce and obtain dominant influence factors on duration estimation.

Validation and reliability tests were performed to determine whether the collected questionnaire data were useful for the next analysis (Basuki, 2018). The validation test used Kaiser-Meyer-Olkin (KMO) and Bartlett test to determine the data validity and feasibility. In this case, the KMO value has to be greater than 0.5 and the significance of the Bartlett test should be below 0.05% for the data to have fulfiled the sufficiency assumption. The reliability test used Cronbach's Alpha to determine the accuracy of data, where its value has to be greater than 0.6. The next step was determining the factors influencing the duration estimation through Measure of Sampling Adequacy (MSA). The

Anti-Image matrix contains a Measure of Sampling Adequacy (MSA) value for each analysed factor. Therefore, it shows the factors suitable for analysis. According to (Santoso, 2015), the MSA value must be greater than 0.5 for the variables to be further predicted and analysed. The last step used Rotated Component Matrix to determine the dominant external variables that were reduced into a factor for use in further analysis.

Duration Prediction using Earned Schedule (ES)

This research used Earned Schedule as duration prediction method because it has been more practical until 2019, based on the latest research by Walter Lipke (Lipke, 2019). Furthermore, the research gap is still relatively new and already validated by real duration data of finished projects. The external factors identified in the previous steps in this study were analysed for their correlation to the estimated duration of construction projects in Jakarta. The duration was estimated by collecting S-curve data for ongoing construction projects and calculating Estimate at Completion (EAC) based on project performance at the time of observation. This EAC calculation was then calibrated to the time per m^2 for each project. Moreover, the duration of each project data was calculated (EAC) using the Earned Schedule method.

Multivariate Regression Analysis

Multivariate regression estimates a single regression model with more than one outcome variable. Regression analysis is a statistical measurement that determines the strength of the relationship between one dependent variable (denoted by Y) and changing or independent variables. The measurable external influence factors comprised three main latent variables, including Economic, Human Resources, and Technologies. Therefore, it is difficult to establish strong relationships between one of the three construction project success variables with the reduced measurable external factors (Sousa et al., 2014).

Multivariate regression was conducted to analyse the correlation between the table result data of duration prediction of ongoing projects calculated by the ES method and the dominant external factors. Also, the analysis included floor numbers and floor areas to accommodate the building characteristic. The result was shown as determinant coefficient Goodness of Fit (R^2) where the value should be greater than 0.7 for a strong sufficient relationship (Moore et al., 2013). Furthermore, this step shows whether the identified dominant external factor affects the project performance based on the duration prediction of the construction.

Result and Discussion

External Factors Analysis

The identification through indicator filtering selection resulted in 12 influencing factors used in questionnaire development. The 12 measured external factors in Table 1b were sorted and converted into notations as described in Table 1c. Furthermore, the questionnaire statement was compiled to be distributed to respondents using a Likert scale as the answer option.

Table 1c According to Table 1b Influence Factor Notation

No	Indicator	Notation
1	Inflation	X11
2	Material Price index	X12
3	Gross Domestic Product	X13
4	Exchange Rate	X14
5	Interest rate index	X15

6	Labor Availability index	X21
7	Labor Experience index	X22
8	Education Level index	X23
9	Health Level index	X24
10	New Technology Availability index	X31
11	Technology Absorption index	X32
12	Innovation index	X33

A total of 53 data were collected from the questionnaires compiled and distributed to various project managers and site engineers. Furthermore, these data need to be tested for validation and reliability to determine whether they could be used in this study.

Validation Test

Kaiser-Meyer-Olkin (KMO) was used to identify the sufficiency of data samples for further analysis using the Factor Analysis Method. The value of these two measures could be obtained using SPSS software. The data is said to fulfil the assumption of sufficiency when the KMO value is greater than 0.5. The results of the feasibility test and data significance are in Table 2.

Table 2 Feasibility Test and Data Significance (KMO and Bartlett)

KMO and Bartlett Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.668
Bartlett's Test of Sphericity	Approx. Chi-Square	207.034
	Df	45
	Sig.	0.000

The KMO-MSA and Bartlett test results in Table 2 show that the KMO value obtained was 0.668, greater than 0.5, while the Sig value was 0.000, smaller than 0.05.

This shows that data sufficiency is fulfiled and Factor Analysis Method could be applied to the existing factors.

Reliability Test

The value of Cronbach's Alpha has to be greater than 0.6 for the collected data to be accurate. The results of the reliability test on the 12 factors based on the questionnaire data are in Table 3.

Table 3 Reliability Test using Cronbach's Alpha

Cronbach's Alpha	Cronbach's Alpha according to item's standard	N from Items
0.843	0.846	12

Table 3 shows that the Cronbach's Alpha (α) coefficient value is 0.843, implying very high reliability. Therefore, the 12 existing factors are reliable enough and useful for further analysis using Factor Analysis Method.

Factors Affecting Duration Estimation

Measure of Sampling Adequacy (MSA) was used for determining the factors influencing the duration estimation by using the Anti-image matrices. Based on the first iteration Measure of Sampling Adequacy (MSA) in Table 4, two of the 12 factors' values are smaller than 0.5, which are X14 and X21. Moreover, the second iteration is generated in Table 5 and it is found that factor's value for X24 is also less than 0.5. Therefore, the further analysis steps will be conducted without X14, X21, and X24 since their factors' value is less than 0.5. From both tables below, it can be seen that the external factor that have been obtained can be reduced for application needs.

Table 4 Correlation Coefficient Matrix from Each Indicator First Time Stage

		Anti-image Matrices											
		X11	X12	X13	X14	X15	X21	X22	X23	X24	X31	X32	X33
	X11	.549[a]	-.293	-.049	.046	-.194	.051	.030	.233	-.362	.082	.000	-.088
	X12	-.293	.565[a]	-.420	.100	-.032	-.332	.136	-.109	.031	-.070	.018	.074
	X13	-.049	-.420	.670[a]	-.193	-.265	.265	.082	-.191	-.053	.142	.006	-.091
	X14	.046	.100	-.193	.491[a]	-.346	-.198	-.005	.004	.292	-.472	-.153	.362
	X15	-.194	-.032	-.265	-.346	.665[a]	.066	-.315	-.220	.230	-.098	.198	.056
Anti-image	X21	.051	-.332	.265	-.198	.066	.378[a]	-.383	.297	-.268	-.069	.165	.059
Correlation	X22	.030	.136	.082	-.005	-.315	-.383	.648[a]	-.318	-.262	.340	-.223	-.328
	X23	.233	-.109	-.191	.004	-.220	.297	-.318	.743[a]	-.320	-.040	-.186	.053
	X24	-.362	.031	-.053	.292	.230	-.268	-.262	-.320	.649[a]	-.294	-.097	.187
	X31	.082	-.070	.142	-.472	-.098	-.069	.340	-.040	-.294	.597[a]	-.199	-.701
	X32	.000	.018	.006	-.153	.198	.165	-.223	-.186	-.097	-.199	.849[a]	-.231
	X33	-.088	.074	-.091	.362	.056	.059	-.328	.053	.187	-.701	-.231	.635[a]

a. *Measures of Sampling Adequacy* (MSA)

Table 5 Correlation Coefficient Matrix from Each Indicator Final Stage

		Anti-image Matrices									
		X11	X12	X13	X15	X22	X23	X31	X32	X33	X24
Anti-image Correlation	X11	.508[a]	-.296	-.057	-.190	.059	.226	.132	-.002	-.123	-.390
	X12	-.296	.668[a]	-.364	.002	.014	-.014	-.092	.083	.092	-.076
	X13	-.057	-.364	.635[a]	-.370	.195	-.287	.108	-.059	-.059	.059
	X15	-.190	.002	-.370	.500[a]	-.368	-.243	-.323	.158	.210	.377
	X22	.059	.014	.195	-.368	.652[a]	-.227	.342	-.189	-.322	-.401
	X23	.226	-.014	-.287	-.243	-.227	.777[a]	.015	-.244	.013	-.288
	X24	-.390	-.076	.059	.377	-.401	-.288	-.238	-.025	.128	.429[a]
	X31	.132	-.092	.108	-.323	.342	.015	.623[a]	-.294	-.636	-.238
	X32	-.002	.083	-.059	.158	-.189	-.244	-.294	.853[a]	-.215	-.025
	X33	-.123	.092	-.059	.210	-.322	.013	-.636	-.215	.697[a]	.128

a. *Measures of Sampling Adequacy* (MSA)

Communality is the proportion of variable variants that could be explained by factors. The greater the communality value, the greater the relation of variables to the factors, as explained by Extraction Communality in Table 6. The table shows that all Extraction Communality values are greater than 0.5, indicating a strong relationship between variables and factors. Initial Communality represents the variant estimation of each variable based on formed factors. The results showed that all Initial Communality values were 1, meaning that the variable variant could be explained by formed factors (Usman & Sobari, 2013).

Table 6 Communality using SPSS®

	Initial	Extraction
X11	1.000	.735
X12	1.000	.633
X13	1.000	.742
X15	1.000	.720
X22	1.000	.522
X23	1.000	.647
X31	1.000	.624
X32	1.000	.731
X33	1.000	.717

Table 6 shows the best factors because they could represent the diversity of used variables that are indicated by the high relationship between the variables and the factors. Furthermore, Rotated Component Matrix was needed to determine the variable to be considered. The value listed to each factor represents a correlation rating between two new against the nine factors included in the new ones.

The correlation coefficient data analysis identified nine indicators related to the factors affecting the duration estimation. These factors are indicators of transformation results according to the availability of data sources. Therefore, they are grouped with a rotational iteration approach for further purposes.

Table 7 Factor Grouping

	Group		
	1	2	3

X32	.854	.046	-.015
X33	.846	-.037	-.022
X31	.784	.076	-.051
X22	.676	.161	.196
X23	.612	.517	.071
X13	.008	.841	.187
X15	.136	.837	-.020
X11	.033	.069	.854
X12	-.103	.480	.626

Further grouping of the three new latent variables in Table 7 is as follows:

(1) Variable 1: Technology Absorption index (X_{32}), Innovation index (X_{33}), New Technology Availability index (X_{31}), Labor experience index (X_{22}), Education Level index (X_{23}).

(2) Variable 2: Gross Domestic Product (X_{13}) and Interest Rate index (X_{15}).

(3) Variable 3: Inflation (X_{11}) and Material Price index (X_{12}).

The influence external factors from Variable group 1 were used as external factors (independent factor X). The dependent factor Y is the duration estimation obtained from EAC (Estimate at Completion) calculation on 44 ongoing construction projects.

Duration Estimation Calculation using ES

A total of 44 S-curve data were collected from ongoing construction projects in Jakarta and its surroundings. The data were analysed using the ES method to predict each final duration (EAC), as seen in Table 8. The average value of duration prediction for ongoing projects is 0.0023 weeks/m^2.

Table 8 Estimate at Completion for Ongoing Construction Projects

No	Project	ES	SPI	EAC	Time Units	Floor area (m^2)	EAC ($week/m^2$)
1	P1	46.01	1.10	115.93	week	38078.5	0.0030
2	P2	19.27	1.01	39.44	month	50000	0.0032
3	P3	48.24	0.96	59.08	week	14800	0.0040
:							:
:							:
42	P42	15.77	1.21	71.73	week	56492	0.0013
43	P43	15.81	1.31	30.11	month	44825	0.0027
44	P44	136.97	1.04	143.59	week	15966.61	0.0090

ES calculation for each project gives average ES from every point of time span up to last point of observation. This is to accommodate the value of Budgeted Cost of Work Performed (BCWP), also known as Earned Value (EV).

The Relationship between External Factor and Estimated Duration

Factor and multiple linear regression analyses were conducted to test the relationship of measurable external factors with the estimated duration of construction projects. The Goodness of Fit (R^2) of the equation regression analysis was used as a sensibility benchmark. Furthermore, variables were transformed to index numbers for unit synchronize.

The equation from regression multivariate analysis between predicted duration and dominant external factors by adding floor numbers and area to accommodate the building characteristic is as follows:

$$Y = 0.126 - 0.509X_{32} + 0.059X_{23} - 0.066X_{33} + 0.306X_{31} + 0.100X_{22} + 0.083X_{FN} - 0.036X_{FA} \quad (6)$$

Where:

- Y is duration prediction in week/m^2.
- Constant = 0.126 is a definite incremental duration of 0.126 weeks/m^2.
- X_{32} = -0.509 is the coefficient of the Technology Absorption index. An increase in the Technology Absorption index by 1 unit decreases the duration by 0.509 weeks/m^2.
- X_{23} = 0.059 is the coefficient of the Education Level index. It means an increase in the Education index by 1 unit raises the duration by 0.059 weeks/m^2.
- X_{33} = -0.066 is the coefficient of the Innovation index.
- X_{31} = 0.306 is the coefficient of the New Technology Availability index.
- X_{22} = 0.100 is the coefficient of the Labor Experience index.
- X_{FN} = 0.083 is the coefficient of the Floor Numbers index.
- X_{FA} = -0.036 is the coefficient of the Floor Area index.

The output of regression analysis in this stage is in Table 9.

Table 9 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.873a	0.763	0.715	0.0228

a. Predictors: (Constant), X7, X4, X3, X5, X6, X2, X1
b. Dependent Variable: Y

From the regression multivariate analysis, the determinant coefficient Goodness of Fit (R^2) value is 0.763. This means that 76.3% of the predicted duration is explained by the independent variables, while the remaining 23.7% is explained by other causes. This result shows that the correlation between external factors and duration prediction of ongoing construction project is higher than the recommended standard of 70% for strong sufficient relationship.

Based on this result, it could be concluded that identified influence external factors could be added to the duration prediction calculation because it will enhance the precision of the predicted duration. By doing this research, it is proven that the additional factors to the prediction calculation of construction project duration could erase the prediction inaccuracy for particular or specific country area that leads to a delay schedule as its accuracy will be increased and improved for practical needs. This research also proves that an effective schedule prediction definitely will affect the level of the country's Gross Domestic Product (GDP) as stated by El-Gohary & Aziz (2014) in literature review section; more precise prediction will support the percentage number of construction sector contribution toward GDP. The prediction of some authors who discuss the same topic with this research can be proved as a valid. This research supports several researches conducted by Chan et al. (2004), Hwang & Lim (2013), and other researchers that have been stated in literature review section that show there are indeed influence external factors that need to be included in prediction duration to support the success of project performance.

Conclusion

A construction project is a temporary activity that requires a balance between time, cost, and quality to achieve the best final goal through maximum management. The final goal and performance have some indirect effects on stakeholders, especially when a delay occurs due to uncertain factors. This delay, which could be caused by internal or external factors, should be avoided to prevent damages to any parties and reduced project performance.

This study started with a literature review to obtain some external factors from the Central Bureau of Statistics (CBS), World Bank (WB), and World Economic Forum (WEF). A total of 12 influence factors were identified, including Inflation, Material Price index, Gross Domestic Product, Exchange Rate, Interest Rate index, Labor Availability

Index, Labor Experience index, Education Level index, Health Level index, New Technology Availability index, Technology Absorption index, and Innovation index. Furthermore, a questionnaire was developed using these factors and distributed to project managers and site engineers as respondents in Jakarta and surroundings. Literature study analysis results show that the external factors could be reduced for application needs. Therefore, Factor Analysis Method was used to reduce the factors into nine dominant influence external factors. These included Technology Absorption index, Education Level index, Innovation index, Technology Availability index, Labor Experience index, Gross Domestic Product, Interest Rate index, Inflation, and Material Price index.

Five dominant external factors were identified as Variable Group 1, including Technology Absorption index, Education Level index, Innovation index, New Technology Availability index, and Labor Experience index. Therefore, they were taken for further analysis using Multivariate Regression Analysis with the addition of floor numbers and area. The multivariate regression analysis determined their correlation with duration prediction of 44 ongoing construction projects calculated by the ES method. The analysis results show a quite good correlation between five influence external factors and duration prediction of ongoing projects because the determination coefficient of Goodness of Fit (R^2) is 76.3%, which means the prediction duration is indeed influenced by the five dominant external factors analysed and could be predicted with the influence of those factors. This analysis allows the estimator to predict the duration of a construction project in a new area. Furthermore, this model is carried out to help a developing country optimize the construction process in duration estimation to boost its growth and development.

As a limitation of this study, data on external factors and duration prediction of ongoing construction projects were only collected in Jakarta and its surrounding. Therefore, this research could be developed by expanding the area of observation. Also, other possible approaches for analysing influence factors and predicting project duration could be used in further research.

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