J-Selaras: A new Innovation Model for Rate Rationalization in Contract Documents

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ABSTRACT

Effective rate rationalization plays a crucial role in modifying tender rates to determine equitable and rational contract amounts, particularly within the context of the construction industry in Malaysia to ensure that contractor prices do not exhibit any front-loading tendencies and establish equitable pricing for variations. Despite the importance of rate rationalization, the Malaysian construction industry grapples with various challenges in the domains of tendering and estimating. These challenges include the scarcity of precise historical data, project intricacy, time limitations, cost variations, restricted technology integration, and the competitive dynamics within the bidding environment. To address these challenges, this study introduces an innovative rationalization model that utilizes the Z-Score Altman model. This model aims to fine-tune the data and establish justifyable rates. and determine reasonable rates through meticulous data integration. Data integration, a widely accepted technique, facilitates smooth data conversion and sharing across diverse applications with different database formats and locations. The proposed model incorporates dynamic algorithms that systematically transfer data between application systems, accommodating various data formats, whether structured or unstructured. Integrating the Z-Score algorithm within the model efficiently filters out extraneous data within the Excel single-sheet file. This algorithm rapidly transfers data to multiple Excel sheets using the macro formulation, recognizing minimum and maximum values, calculating modified means, and employing cut-off analysis to narrow down the rates deemed most favorable. This research rigorously evaluates rates put forth by successful tenderers, staying within established parameters, and providing a durable algorithm that outlines the calculations and conditions guiding this thorough evaluation.

Keywords: Automated Data; Z-Score Altman Algorithm; Rate Rationalization; Excel sheet; construction

INTRODUCTION

Investigating the cognitive mechanisms behind rational decision-making is an intriguing area of research, with significant implications for improving performance in various fields. Decisions are typically based on the information available and the options presented to achieve the best possible outcomes. However, uncertainty in decision-making adds complexity to this process. A key aspect of decision-making is expected utility theory, which suggests that individuals choose actions that maximize gains or minimize losses, influenced by their risk attitudes. Each person's unique risk tolerance and psychological characteristics are crucial in shaping their decision-making approach. The interplay between risk aversion and the psychological concepts found in prospect theory (Kahneman and Tversky, 1979) is central to understanding how decisions are made.

Simon (1955) underscores the gap between interpreting rational behavior through a psychological lens and empirically analyzing decision-making processes. This requires accounting for environmental factors, individual characteristics, and numerous variables that influence choices, ultimately leading to optimal outcomes. Cognitive biases, which reflect psychological and emotional tendencies, play a critical role in shaping decision-making. In a similar vein, Sonnemann et al. (2013) stress the importance of understanding the variables that impact decisions in particular contexts and acknowledging how biases can affect broader market evaluations.

Utilizing computational algorithms offers a powerful solution to mitigate biases and improve transparency and accountability in decision-making processes. However, in construction projects where complex relationships exist among multiple stakeholders, all bound by contractual obligations and penalties, arriving at rational pricing decisions can be highly challenging. While project rates are initially agreed upon within fixed timelines, they often fluctuate due to changes in market conditions and material availability. Consequently, in traditional contract frameworks, the distribution of work is shaped by variables such as overall project workload, risk allocation, and contingency allowances.

The construction industry represents a vast network of interconnected sectors, underpinned by diverse funding models and market dynamics. Its activities span various stages, from transforming raw materials like timber, sand, and water into intermediate products such as bricks, timber planks, and concrete, to creating functional, market-ready items. Each phase is shaped by unique market conditions and involves a wide array of professionals and laborers, contributing to the overall production process. This progression, from raw materials to finished goods, takes place in distinct environmental contexts, each with specific requirements critical for moving the project forward. Within this intricate and evolving landscape, construction professionals must navigate uncertainties influenced by external factors, constantly assessing and adjusting their risk tolerance to remain competitive and ensure project success.

In Malaysia, rate rationalization is a technique used to adjust the rates offered by winning bidders to ensure fair and reasonable contract pricing. This process modifies the rates of items listed in the Bills of Quantities (bq) (Waheeb, 2023) without altering the overall contract sum. The aim of rationalizing the Bills of Quantities (rbq) is to prevent contractors from inflating prices upfront and to encourage equitable pricing, especially for items that may change during the project.

In the procurement process for Jabatan Kerja Raya (JKR) Malaysia projects, the tender documents include Bills of Quantities (bq), detailing all items for which tenderers must submit prices (Raya, 2015). Only bids that offer the most competitive and reasonable prices within a specified range are considered for evaluation. After completing the evaluation, the approval committee selects a tenderer for appointment, formalized through a Letter of Acceptance. Before the contract is finalized, the rates in the bq undergo rationalization, with the revised bq rates becoming the official contract rates. This rationalization is carried out in accordance with the terms outlined in JKR 203A (Rev. 1/2010) and the Malaysian government's policy, updated in Treasury Circular PK4 on November 29, 2022, by the Ministry of Finance Malaysia (Ministry of Finance Malaysia, 2022). The contractor's prices and rates in the bq are adjusted to ensure they are reasonable, with any errors or omissions in the pricing or calculations corrected before the contract is signed, maintaining the integrity of the tender price.

As per the guidelines outlined, it is specified that contracts should be executed within a four-month timeframe after the contractor accepts the Letter of Acceptance. Yet, the concurrent initiation of numerous government projects in a phased plan has resulted in delays in the process of signing contracts, surpassing the prescribed four-month timeframe, as documented in the Auditor General's Report in 2012 (Astro, 2020). These delays have had consequences on contractor payments and the punctual delivery of government projects.

In reaction to this, the Director General of Public Works Malaysia (KPKR) (Raya, 2015) has introduced a pivotal performance metric intending to achieve the simultaneous signing of the Letter of Acceptance and contract documents, as stipulated in the Director General Public Works Malaysia Instruction Letter of 2020. Due to the intricacy and time-consuming nature of the rationalization process, the formulation development model for bq rationalization is incorporated into the model development for System Rate Rationalization Online (J-Selaras) process. This endeavor aims to simplify and expedite the rationalization process to fulfill contractual obligations and facilitate the smoother implementation of projects.

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Related Works

In the practices of JKR (Raya, 2015), the purpose of rationalizing the Bills of Quantities (bq) is to assess the pricing proposed by contractors, ensuring they are equitable and that similar items are standardized prior to contract finalization. This rationalization process is separate from any adjustments to the contract amount specified in the Tender Form. It is essential to correct any pricing discrepancies in the bq, and rates must be thoroughly examined to guarantee uniformity among items that share similar descriptions in the bq.

Currently, the rationalization of Bills of Quantities (rbq) is performed manually using Microsoft Excel templates. The evaluation of rates involves comparing them with those from similar past contracts or determining them based on current market prices. This manual approach is labor-intensive and time-consuming, which delays the signing of contracts. Consequently, this research proposes an innovation that integrates the existing cut-off formula used in JKR's tender evaluation into the RBQ analysis. This cut-off formula determines the number of tender prices to be assessed by applying standard deviation and the Z-Score (ZS) formula (Hafeez et al., 2022), allowing for the filtering of tender prices within a range of plus or minus 15% of the adjusted mean.

Before the filtering algorithm is implemented, the bq is transformed and stored in a MySQL database within the J-Selaras system in a cloud environment. At this stage, it is important to note that the list of bq prices has yet to be standardized. The prices generated in the bq must conform to the standardized pricing set by the construction company, as illustrated in this case study involving JKR Malaysia. All material prices listed in the bq are standardized according to specific formulas, including the ZS formula. This ZS formula for bq pricing encompasses parameters such as Standard Deviation (SD), Minimum, Maximum, and cut-off values. The pseudocode demonstrating the application of the ZS formulation to a bq is presented in Fig. 1.

A structured representation of the pseudocode for applying the ZS formulation to a bq within the J-Selaras system is depicted in Fig.1.

```
Start
1. Compute the rMin and rMax
2. Analyse the prices with cut-off
3. J-Selaras proposes the BQ price
   3.1 If the proposed BQ price is > 115% and < +10% of the standardized price
         3.1.1 J-Selaras accepts the proposed price
   3.2 Else
         3.2.1 J-Selaras accepts the cut-off price
End
```

Fig.1. Pseudocode in Z-Score formulation

The ZS is computed by calculating the mean and standard deviation of a specific attribute. It is a metric indicating the difference between an individual value and the population mean, divided by the population's standard deviation. It standardizes each feature to possess a mean of zero and a variance of one. The concept of the ZS is grounded in applying the mathematical Gaussian curve or 'Bell-shaped' curve to the analyzed data. The ZS, denoted as Z in, is expressed as follows:

$$ZS = \frac{x_i - \bar{x}}{s}$$

In the provided equation, x_i represents an individual value, $\bar{x}$ denotes the mean of the samples, and s signifies the standard deviation of the samples. The ZS technique was integrated into the study to facilitate the comparison of each rate in the bq among all short-listed tenderers, the successful tenderers, and the department's cost estimation. Conversely, the proposed rates in the bq, to be mutually agreed upon by the successful tenderer, will be automatically generated by the system using the cut-off formula. This formula computes the rate of an item description by considering the average rates of all short-listed tenderers, which encompass both the successful tenderer and the department's estimate. Both the cut-off formula and the ZS technique replicate the structure of the tender evaluation system. The cut-off principle establishes the lowest acceptable rate for approval. If the rate falls below this threshold, the tenderer may encounter challenges in fulfilling the project requirements.

Following statistical methods, determining the cut-off rate depends on the 'Mean' and 'Standard Deviation' of the rates supplied by the shortlisted tenderers, encompassing the Department's Estimates (AJ) rates, after the exclusion of any outlier rates. The cut-off rate is within the range of not exceedingly above +10% (<+10%) and not exceedingly below -15% (<-15%). After uploading all tenderer price bq data into the J-Selaras system, the system autonomously performs the analysis using the prescribed cut-off and the ZS formula. At the same time, the J-Selaras system proposes the contractor rate if it falls within the cut-off range. However, it suggests the cut-off rate if the contractor rate exceeds this specified range.

In concluding the bq for the contract document, the choice of a reasonable rate can be determined by weighing the decision to accept the rate of a successful tenderer, the rate generated by the system, rates from past projects, or the current market review rates. The J-Selaras system adds value by functioning as a central hub for collecting data on price rates and serves as a reference point, particularly in the preparation of departmental estimates for new projects.

J-Selaras Development Model

The six steps tendering process is depicted in Fig. 2. Step 1 involves populating the bq using CostX with the PostgreSQL database system and converting it into Excel macro format, which is then stored in the Cloud database. In Step 2, the bq estimation in Excel format is distributed to both successful and shortlisted tenders, sourced from the tender appraiser officer. Step 3 entails uploading the Excel-format bq from the estimation department, awarded to successful tenderers, into the JSelaras system. Step 4 involves the JSelaras system generating a pricing comparison table. In Step 5, each price rate for every bq undergoes analysis using cut-off concepts, including mean, maximum, average, and standard deviation figures. Before applying the cut-off formula, the adjusted price is reviewed by the appointed reviewer and the verified officer in charge in Step 6. The J-Selaras system verifies arithmetic errors, ensuring that the adjusted price aligns with the actual price in the contract tender as stated in the Letter of Acceptance (SST). Fig.3 presents the proposed model architecture.

```
+---------------------------------------------------+
|                 Tendering Process                 |
|                    (Figure 2)                     |
+---------------------------------------------------+
|                                                   |
|  1. Fill up BQ using CostX with PostgreSQL        |
|     database system. Convert to Excel macro       |
|     format and store in Cloud database.           |
|                                                   |
|  2. Provide softcopy of BQ estimation in Excel    |
|     format to successful and shortlisted          |
|     tenderers, obtained from tender appraiser     |
|     officer.                                      |
|                                                   |
|  3. Upload BQ in Excel format from estimation     |
|     department, awarded to successful tenderers,  |
|     to JSelaras system.                           |
|                                                   |
|  4. JSelaras system creates pricing comparison    |
|     table.                                        |
|                                                   |
|  5. Analyze price rates for each BQ using cut-off |
|     concepts such as mean, max, average, and      |
|     standard deviation figures.                   |
|                                                   |
|  6. Review adjusted price before cut-off formula  |
|     by appointed reviewer and verified officer.   |
|     JSelaras system checks for arithmetic errors, |
|     matching adjusted price with actual price in  |
|     contract tender as stated in Letter of        |
|     Acceptance (SST).                             |
|                                                   |
+---------------------------------------------------+
```

Fig. 2. Steps involved in the data transfer process from CostX to Excel format and the BQ Tender price adjustment rate determination process

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The J-Selaras conversion tool is developed based on a filtering algorithm, as illustrated in Fig. 3.

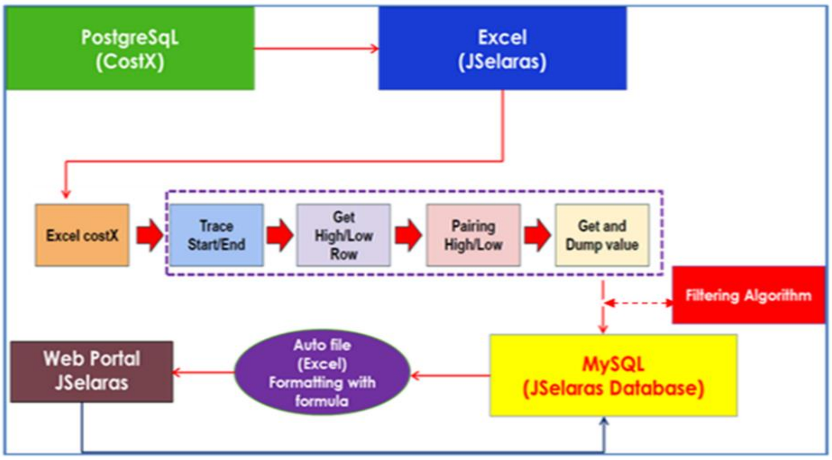

Fig. 3. J-Selaras Model

The detailed specifications of the bill of quantity (bq) are initially input into the CostX system, which employs a PostgreSQL database. Afterward, the bq specifications are downloaded from the CostX system in Excel format and transferred to the JSelaras system through a filtering algorithm. This filtering algorithm operates in several steps:

Tracing Keywords: The algorithm begins by tracing the 'Start' and 'End' keywords within the downloaded Excel file.

Defining Range: Next, it highlights the cells covering from the 'Start' to the 'End' to determine the range from the highest row to the lowest row.

Pairing Cells: The cells involved in the highest and lowest rows are paired, and all values within these cells are extracted.

EXPERIMENT AND RESULTS

In this case study, two experiments was done:

Experiment 1 – STAIRCASE - 64mm diameter x 2mm thick Mild Steel Hollow Section (MSHS) handrail welded to 15mm, diameter mild steel bar welded to 38mm x 38mm x 1.6mm thick mild steel baluster with G.I fish tail embeded into concrete and 25mm diameter x 1.2mm thick mild steel railing and painting works. Refer to the Fig. 4.

ITEM	DATA	ANALYSIS
STAIRCASE *64mm diameter x 2mm thick Mild Steel Hollow Section (MSHS) handrail welded to 15mm diameter mild steel bar welded to 38mm x 38mm x 1.6mm thick mild steel baluster with G.I fish tail embeded into concrete and 25mm diameter x 1.2mm thick mild steel railing and painting works* *Item : 900mm High railing* Unit : m	Rate Successful Tenderer : **RM 150.00** ***(USD31)*** Rate DE : **RM 200.00** ***(USD41)*** Rate Evaluated Tenderer No. 1 : RM 27.00 ***(USD5)*** Rate Evaluated Tenderer No. 2 : RM 150.00 ***(USD31)*** Rate Evaluated Tenderer No. 3 : RM 132.00 ***(USD27)*** Rate Evaluated Tenderer No. 4 : RM 74.30 ***(USD15)*** Rate Evaluated Tenderer No. 5 : RM 309.00 ***(USD64)*** Rate Evaluated Tenderer No. 6 : RM 181.00 ***(USD37)*** Rate Evaluated Tenderer No. 7 : RM 128.16 ***(USD26)*** Rate Evaluated Tenderer No. 8 : RM 190.00 ***(USD39)*** Rate Evaluated Tenderer No. 9 : RM 150.00 ***(USD31)*** Rate Evaluated Tenderer No. 10 : RM 300.00 ***(USD62)*** ****DE - Departmental Estimate***	1) **rMin** **RM 128.16** ***(USD26)*** 2) **rMax** **RM 200.00** ***(USD41)*** 3) Mean RM 161.59 *(USD33)* 4) Adjusted Mean RM 180.80 *(USD37)* 5) Standard Deviation RM 26.51 *(USD5)* 6) Adjusted Mean – 15% of Adjusted Mean RM 153.68 *(USD31)* 7) Adjusted Mean – Standard Deviation RM 154.28 *(USD32)* 8) **Cut-Off** **RM 154.28 @** **RM 154.00** ***(USD32)*** 9) Median - **10) Model Proposed Rates** **RM150.00** ***(USD31)***

Fig. 4. Detail information of Experiment 1

Table 1 shows the primery data to be used in our experiment. It's consists of ten (10) tenderers and Departmental Estimate Rate. Subsequently, primer data will be eliminated to produce cleaned data by using ZS formulation. Four (4) tenderers has been removed because of the value of ZS produced is less than -1.5 or more than 1.5.

Table 1: Result of STAIRCASE Experiment 1

Tenderer's	Amount	1st			2nd			3rd			8th		
		Mean	SD	Result	Mean	SD	Result	Mean	SD	Result	Mean	SD	Result
		167.41	80.44		150.68	38.06		161.59	26.51		161.59	26.51	
X1.	27.00	-1.75		X			X			X			X
X2.	150.00	-0.22		/	-0.02		/	-0.44		/	-0.44		/
X3.	132.00	-0.44		/	-0.49		/	-1.12		/	-1.12		/
X4.	74.30	1.16		/	-2.01		X			X			X
X5.	309.00	1.76		X			X			X			X
X6.	181.00	0.17		/	0.80		/	0.73		/	0.73		/
X7.	128.16	-0.49		/	-0.59		/	-1.26		/	-1.26		/
X8.	190.00	0.28		/	1.03		/	1.07		/	1.07		/
X9.	150.00	-0.22		/	-0.02		/	-0.44		/	-0.44		/
X10.	300.00	1.65		X			X			X			X
XDE	200.00	0.41		/	1.30		/	1.45		/	1.45		/

Experiment 2 – EXTERNAL FLOOR FINISHES - 20mm Thick cement and sand (1:3) rendering to floor as specified. Item : To level, falls and crossfalls and to slope not exceeding 15 degrees from horizontal. Refer to the Fig. 5.

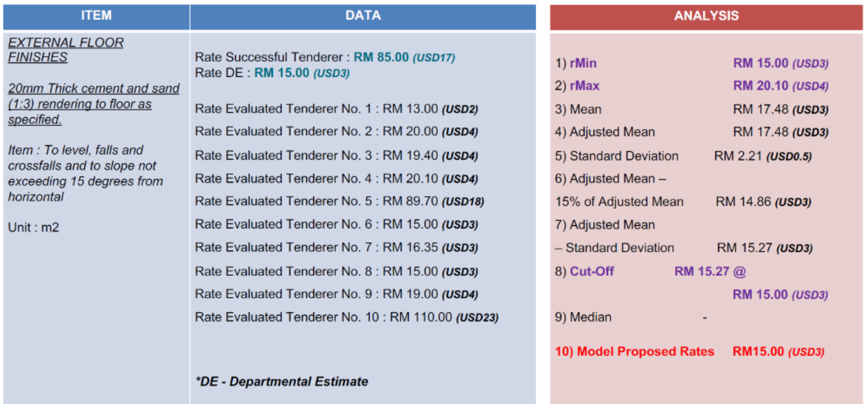

Fig. 5. Detail information of Experiment 2

Table 2 shows the primary data to be used in our experiment. It's consists of ten (10) tenderers and Departmental Estimate Rate. Subsequently, primery data will be eliminated to produce cleaned data by using ZS formulation. Three (3) tenderers has been removed because of the value of ZS produced is less than -1.5 or more than 1.5.

Table 2: Result of EXTERNAL FLOOR FINISHES Experiment 2

Tenderer's	Amount	1st			2nd			3rd			8th		
		Mean	SD	Result	Mean	SD	Result	Mean	SD	Result	Mean	SD	Result
		32.05	32.33		16.98	2.51		17.48	2.21		161.59	26.51	
X1.	13.00	-0.59		/	-1.59		X			X			X
X2.	20.00	-0.37		/	1.20		/	1.14		/	1.14		/
X3.	19.40	-0.39		/	0.96		/	0.87		/	0.87		/
X4.	20.10	-0.37		/	1.24		/	1.19		/	1.19		/
X5.	89.70	1.78		X			X			X			X
X6.	15.00	-0.53		/	-0.79		/	-1.12		/	-1.12		/
X7.	16.35	-0.49		/	-0.25		/	-0.51		/	-0.51		/
X8.	15.00	-0.53		/	-0.79		/	-1.12		/	-1.12		/
X9.	19.00	-0.40		/	0.80		/	0.69		/	0.69		/
X10.	110.00	2.41		X			X			X			X
XDE	15.00	-0.53		/	-0.79		/	-1.12		/	-1.12		/

Conclusion of the result for this experiments. Figure 6 shows the primery data to be used in our experiment. It consists of ten (10) tenderers and Departmental Estimate Rate. Subsequently, primary data is eliminated to produce cleaned data by using ZS formulation.

Experiment	Description	Methodology	Results	Statistical Tools Used
Experiment 1: **Staircase Construction Rate Validation**	Testing rate rationalization using Z-Score analysis on staircase railing pricing.	Rates from ten tenderers and a Departmental Estimate (DE) were analyzed using Z-Score to filter outliers and determine acceptable rates.	The accepted rate was RM 150.00, aligning closely with the calculated cut-off values, confirming the model's reliability.	Z-Score, Adjusted Mean, Cut-Off Analysis
Experiment 2: **External Floor Finishes Rate Validation**	Analysis of external floor finishes to validate the model's effectiveness across different construction scopes.	Similar to Experiment 1, this used rates from ten tenderers for floor finishes. Rates were standardized using Z-Score and checked against DE.	The final approved rate was RM 85.00, which was outside the typical range, thus the cut-off rate of RM 15.00 was applied as the proposed rate.	Z-Score, Standard Deviation, Variance Calculation

Fig. 6. Conclusion for Primary Data used in the Experiments

Next is the result for system performance shows in Table 3. It displays the results of the simulation on bq generation, comparing the manual process with the automated JSelaras system.

Table 3. The evaluation on the execution time in seconds (s) among Excel manual bq generation and JSelaras bq generation

Project	**File Size (KB)**	**Manual Time Process (MS Excel)(s)**	**J-Selaras Tools time Process (s)**
BQ for Project A	297	18000	3
BQ for Project B	301	21600	4
BQ for Project C	294	18000	3
BQ for Project D	424	25200	4
BQ for Project E	600	27000	5

The performance metric for comparing the manual process with the CostX system to the proposed J-Selaras system in generating the bq from Project A to Project B is determined based on the time difference in execution. The time taken for processing, measured in seconds, is documented, and the results from Table 3 are presented visually in Fig. 7.

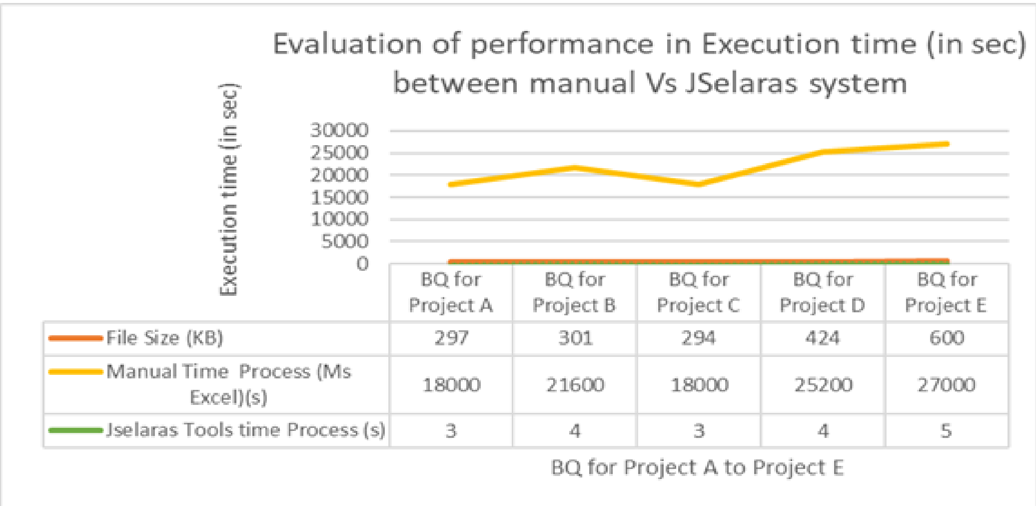

Fig. 7. The execution time of bq generation between the manual CostX with the proposed JSelaras system

The recorded data pertains to five projects (Project A, Project B, Project C, Project D, and Project E), including the Excel file size in kilobytes (KB) and the execution time for processing each project. A stark contrast is observed between the manual process, which takes over 18,000 seconds, and the JSelaras system, which generates the bq in just 3 to 5 seconds. With the automated conversion tool like JSelaras, there's a remarkable 6,000-fold reduction in bq generation time.

CONCLUSION

The adoption of the J-Selaras system has greatly enhanced efficiency in terms of time and has streamlined the manual conversion process, which was conventionally managed by human resources. Utilizing this converter, the likelihood of error rates is expected to decrease due to the automated conversion from Excel format source files in the CostX system. Furthermore, when data is recorded and stored in a centralized database such as MySQL on a cloud-based platform, the record-keeping mechanism becomes structured to ensure convenient storage and retrieval for the administrator. Cloud database storage resists maintenance difficulties, enhancing overall reliability. The J-Selaras system serves as a comprehensive construction tool, encompassing various tasks in construction management. It caters to both upper management and operational decision-makers, facilitating informed decision-making at all levels of the construction process.

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