E-ISSN: 2746-9107 | P-ISSN: 3047-4248

JOURNAL OF SOCIETY INNOVATION AND DEVELOPMENT

Comparative Analysis of Bid Pricing Strategies in E-Procurement Ship Docking Tenders in Indonesia Using the Friedman and Gates Models

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Abstract

Indonesia's shipbuilding sector has significant maritime potential; yet escalating rivalry in ship docking tenders necessitates that contractors establish bid prices sufficiently low to get contracts while still ensuring a satisfactory profit margin. Research Objective: This research seeks to compute and evaluate optimal markup values and anticipated profits using the Friedman and Gates bid price strategy models to determine the best competitive model for e-procurement ship docking tenders in Indonesia. The study employs quantitative comparison analysis with finalized ship docking tender data from the LPSE Ministry of Transportation database for the years 2021 to 2023. Methodology: Following the application of selection criteria, the research examined 22 ship docking tender samples from 27 shipyard contractors, using single-normal and multi-normal distribution methods to estimate winning probabilities, optimal markups, and expected profits. Key Findings: The findings indicate that the Friedman model utilizing a multi-normal distribution yields the lowest optimal markup values, between 5% and 20%. In contrast, the Friedman single-normal distribution results in 12% to 13%, the Gates multi-normal distribution ranges from 6% to 20%, and the Gates single-normal distribution consistently maintains a value of 17%. Key Findings: Consequently, the Friedman model with a multi-normal distribution is recognized as the optimal bidding method for enhancing the likelihood of winning bids by offering a more competitive bid price. The results suggest that shipyard contractors may use past tender data and bidding models to achieve a balance between competitiveness and profitability, mitigate price uncertainty, and enhance strategic decision-making in public ship docking bids.

Keywords: Expected Profit, Friedman Model, Gates Model, Multi-Normal Distribution, Single-Normal Distribution

Introduction

Indonesia has significant marine industry potential, especially in the shipbuilding and ship repair industries. In a 2022 announcement from the Indonesian Ministry of Industry, it was reported that there are 250 shipbuilding businesses in Indonesia, including five State-Owned Enterprises (BUMN). The cumulative installed production capacity of Indonesian shipbuilding enterprises amounts to one million deadweight tonnes (DWT) annually for new vessel construction. The Ministry of Industry asserts that the operational efficiency of new shipbuilding

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Received: March 13, 2026 - Accepted: June 20, 2026 - Published online: June 28, 2026

manufacturing capacity is comparatively low, fluctuating between 35% and 40%. Simultaneously, ship repair capacity prevails, reaching 12 million DWT annually with a utilisation rate of over 70%. According to data from the Association of Indonesian Ship and Offshore Facilities Industry Companies (IPERINDO) in 2018, around 10,000 intact ships entered Indonesia from 2006 to 2018, with a total worth of up to IDR 100 trillion. This situation indicates that ship repair services have a more significant impact on shipbuilding enterprises than new shipbuilding endeavors.

In project-based businesses, bidding strategy is a critical academic and practical subject, since contractors must establish a bid price that enhances their likelihood of success while ensuring profitability. The tender process is essential since it encompasses a sequence of operations designed to identify the most appropriate business to execute a project via a bidding procedure. In shipbuilding and repair projects, the tender process influences both the likelihood of a contractor securing a job and the potential income derived from it. Consequently, contractors need a robust and well-devised bidding strategy. An essential aspect of bidding strategy is establishing a bid price that is below that of rivals while yet allowing for profit generation. The Friedman model (1956) and Gates model (1967) are bidding strategy frameworks used in prior research to determine optimal markup prices and maximum anticipated earnings in project-based endeavours. These models provide a mathematical foundation for contractors to assess bid pricing by analysing past tender data, likelihood of winning, optimal markup, and anticipated profit.

Nonetheless, the use of bidding strategy models in maritime projects, particularly ship docking tenders in Indonesia, remains constrained. This results in a knowledge disparity, since ship docking tenders possess competitive attributes that allow several contractors to compete, while only one contractor may get each tender. Moreover, contractors have a pricing conundrum, as a bid price that is excessively high may diminish the likelihood of success, but a bid price that is excessively low may compromise profitability. Shipbuilding firms want dependable references for establishing bid pricing, as erroneous markup choices might diminish competitiveness or anticipated profit. This research tackles the gap by comparing bidding models and statistical methods to identify the most appropriate optimal markup for Indonesian e-procurement ship docking tenders.

This study seeks to compute and contrast markup values using the Friedman and Gates models to determine the best appropriate bidding approach for ship docking tenders. This study aims to address the following enquiries: what optimal markup values are produced by the Friedman and Gates models using single-normal and multi-normal distribution methodologies? Which model generates the most competitive bidding strategy based on optimal markup and expected profit? In what manner may past tender data serve as a benchmark for establishing bid pricing in ship docking projects? This study examines bid price techniques in Indonesian ship docking tenders.

This research uses historical auction data from ship docking projects completed during the 2021–2023 period on the LPSE page of the Ministry of Transportation. The data are analyzed using two bid pricing strategy models, namely the Friedman model and Gates model. Each model is calculated using two statistical distribution approaches, namely single-normal distribution and multi-normal distribution. These approaches are used to estimate the probability of winning, optimum markup value, and expected profit. The comparison between models is then used to determine which strategy produces the most competitive bid price for ship docking tenders.

This study is significant for its practical implications for shipbuilding enterprises and its scholarly contributions to bidding strategy studies in marine projects. The findings may assist contractors in enhancing their likelihood of securing contracts while accounting for anticipated profit. This study academically enhances the sparse discourse about the use of the Friedman and Gates models in ship docking and marine tender projects. This research aims to enhance strategic decision-making in competitive public ship docking tenders.

In this study, markup denotes the supplementary value or percentage included into the projected project cost to ascertain the bid price. The bid price denotes the proposed amount presented by a contractor in the tendering procedure. Expected profit is the anticipated profit derived from the combination of the markup value and the likelihood of securing the tender. The Friedman model and Gates model are a bidding strategy framework used to determine optimal markup and anticipated profit. Single-normal distribution and multi-normal distribution denote the statistical methodologies used to analyze historical biding data and assess tender-winning odds.

This document is structured into many primary parts. The introduction delineates the study's background, pertinent literature, research gaps, objectives, research questions, methodologies, importance, and essential terminology. The theoretical framework addresses project management, cost estimating, markup, anticipated profit, procurement, tendering, and bidding models. The methods section delineates the study strategy, data sources, data gathering methodology, sampling criteria, and data analysis approaches. The findings and discussion sections elucidate and analyze the computational outcomes of the Friedman and Gates models using single-normal and multi-normal distributions. The conclusion encapsulates the main results and offers suggestions for contractors and further study.

Theoretical Background

Project Management

The definition of a project can be interpreted as a temporary activity that lasts for a limited period, with the allocation of certain resources intended to conduct tasks whose targets have been clearly outlined. Referred to Pujiyono (2017), broadly speaking, project management is the science and art of planning, organizing, directing, coordinating, and controlling people and materials to achieve specific project objectives.

a) Project Cost Estimation

In a project, there are several estimation methods that can be used to prevent losses. Quoting from Suanda (2020), One commonly used method is analogous estimating. Analogous estimating is a method that uses ratios of project length, cost, duration, size, complexity, and thresholds as the basis for estimates. Second is parametric estimating. Parametric estimating is a method that combines statistical relationships between historical data and other variables to estimate activity parameters such as cost and duration.

b) Implementation of Cost Estimation

To create an accurate and robust cost model, there are several steps that must be implemented by the estimator. Referring to the basic theory from Kerzner (2017), project cost budget estimation is conducted through several main steps: defining work requirements, compiling a logical network, developing a Work Breakdown Structure (WBS), determining the cost of each part of the WBS, and reviewing costs with functional managers.

c) Mark Up

Markup is the supplementary amount incorporated into overall costs to ascertain a product's selling price or project bid value. Kasa and Herzanita (2021) assert that markup is contingent upon the company's aims, particularly profit maximization. A substantial markup may enhance profit margins but diminish the likelihood of securing a contract, whereas a little markup may boost the probability of winning yet provides reduced profits. Project markup can be produced by formulation of:

Mark up = B / C

Whereas:

B = Bid Ratio

C = Estimate Cost

d) Expected Profits

Profits derived from the difference between the total cost and the offer price plus the markup value. In accordance with Patmadjaja (1999), the likelihood of being the lowest bidder decreases as the bid price increases. Consequently, the anticipated profit must be established at the utmost. Bahman-Bijari (2010) defines expected profit as the sum of two values: the markup (m) and the probability of victory (Pw) over competitors. The anticipated profit is determined by employing the subsequent formula:

$E(P) = p\,(b - c)$

Whereas:

E(P) represents the anticipated profit.

p = Probability of winning
b = Bid
c = Estimated cost

Procurement

Procurement refers to the process of obtaining products and services in both governmental and commercial sectors. In Indonesia, government procurement includes items, building projects, advisory services, and other services, as stipulated by Presidential Regulation (PERPRES) No. 12 of 2021.

Tender

Tender process includes designing and writing a tender proposal, complete with tender management criteria. Tender management involves comprehensive oversight of the tender process, from the planning process to submission. This includes tasks such as designing and writing a tender proposal, managing documents, communications, and other tasks related to the tender process. Nurmala (2009) stated that in government tender, contract conditions are general provisions that must be included in the work contract, which aim to provide understanding, guidelines and limitations for users and service providers in implementing the contract.

Bidding Model

Friedman Model, L.A. Friedman introduced the bidding strategy method in 1956 to determine optimum markup and maximum expected profit. The Friedman model helps contractors estimate a competitive bid price based on previous similar projects while maximizing expected profit. It uses winning probability formulas for known and unknown competitors (Tarranza in Prabhamandala & Yusuf Latief, 2014). The model is useful because actual project costs remain uncertain after winning the tender (Takano et al., 2014), and it is commonly applied in lowest-bid tender competition (Bahman-Bijari, 2010). The formulation as mentioned below.

Winning probability for known competitors:
P(Co Win /Bo) = P(Bo<B1) x P(Bo<Bi) x ... x P(Bo<Bn)
Whereas:
P(Co Win/Bo) = Winning probability against all known competitors
P(Bo<Bi) = Probability of a markup with CDF
Ba = Average bid price.
Bo = Contractor's bid price.
Winning probability for unknown competitors:
P(Co Win /Bo) = P (Bo < Ba)^n
Whereas:
P(Co Win/Bo) = Winning probability against all unknown competitors.
n = Number of competitors.
Ba = Average bid price.
Continue calculating the expected profit:
E(P) = (Bo – Us. C) x P (Co Win/Bo) (2.6)
Whereas
E(P) = Expected profit.
Us = Ratio of actual costs to estimated costs.
Bo = Contractor's Bid Price.
C = Estimated project cost.

Gates Model

The Gates (1967) model are comparable with Friedman model (1956) and in that they both employ winning probability formulas for known and unknown competitors in sealed bidding (Skitmore et al., 2007). Nevertheless, the Gates model deviates from the norm in its estimation of the likelihood of success. It forecasts the likelihood of submitting the lowest proposal and establishes the optimal markup to optimise profit (Ballesteros-Pérez et al., 2023). In this paradigm, competitors who are ideal or like one another have an equal likelihood of prevailing

(Christodoulou, 2004). In accordance with Skitmore et al. (2007), the probability of winning can be ascertained by:

Winning probability for known competitors:

$$P(CoWin/Bo) = \frac{1}{1 + \sum_{i=0}^{n} \frac{1 - P(Bo < Bi)}{P(Bo < Bi)}}$$

Winning probability for unknown competitors:

$$P(CoWin/Bo) = \frac{1}{1 + n\,\frac{1 - P(Bo - Ba)}{P(Bo < Ba)}}$$

Continue calculating the expected profit:

$$E(P) = (Bo-C) \times P(CoWin/Bo)$$

In this method, Gates assumes that the estimated cost is the same as the actual cost.

Methods

Research Design

This research employs a quantitative comparative approach to examine and contrast bid pricing techniques in Indonesian e-procurement ship docking tenders. A quantitative design is used since the study depends on numerical tender data, including bid prices, predicted project expenses, markup values, winning probabilities, and anticipated profit values. This work employs a comparative design to analyze two biding strategy models, namely the Friedman model and the Gates model, using two statistical distribution methods: single-normal distribution and multi-normal distribution (Figure 1).

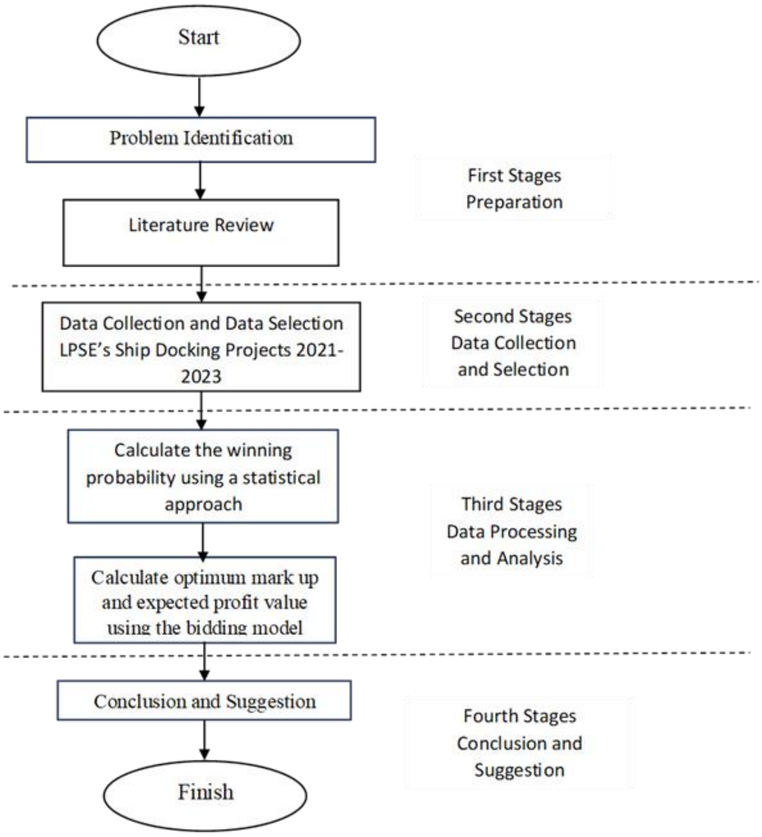
The study design is organized into many methodical phases. The first phase involves preparation, including issue identification and a study of literature. This step involves identifying the research challenge, which arises from the need for shipyard contractors to establish competitive bid prices while ensuring profitability. The literature research is performed to comprehend pertinent theories associated with project cost estimating, markup, anticipated profit, tendering, and bidding models.

The subsequent phase involves collecting and selection of data. This research utilizes secondary data sourced from the Electronic Procurement Services (LPSE) website of the Ministry of Transportation. The data comprises ship docking tender proposals finalized between 2021 and 2023. The data are picked according to criteria, including completed ship docking tenders, a minimum of two participating contractors, and tenders executed utilizing the lowest-price knockout procedure.

The third phase involves data processing and analysis. At this step, the chosen tender data are analyzed to compute the chance of success utilizing statistical methods. Subsequently, the optimal markup and anticipated profit values are determined using the Friedman and Gates bidding models. The outcomes from each model and distribution method are then analysed to determine which technique yields the most advantageous bid price.

The fourth step includes the conclusion and recommendations. At this step, the study results are analyzed to identify the optimal bidding strategy for ship docking tenders. The findings are derived from the comparison of optimal markup levels with anticipated profit values. Subsequent recommendations are offered for shipyard contractors and prospective researchers. This study methodology offers a systematic framework for the collection, processing, analysis, and interpretation of tender data to ascertain the optimal bid price approach for ship docking projects.

Figure 1: Research Design



Data sources

The tender data used is tender data for ship projects found on the page (LPSE) page which can be accessed publicly with the criteria being tender for ship docking projects that have been completed in the 2021-2023 period with a minimum of 2 (two) contractor companies participating in the tender, a minimum HPS or unit cost price value of IDR 2,000,000,000 with a lump sum, unit price and combined contract type, and executed using the lowest price knockout system method. The sample consisted of 22 ship docking tender offers from 2021-2023 and 27 shipyard businesses in the tender.

Data Collection and Procedure

The data collection of this research was done by collecting the tender information of the ship docking project which can be accessed on the Electronic Procurement Services (LPSE) site of the Ministry of Transportation on the "Dephub" page. Judgmental sampling was used to refine the available tender data, which involves the selection of samples based on criteria that fit the characteristics of the situation at hand. Accordingly, each shipyard contractor included in this sample of ship docking tenders was assigned a code number for purposes of data processing. The resulting sample was categorized by the maximum number of participants in tenders and active participation of contractors in tender procedures.

Population in this study was tender data of ship projects in 2021-2023 which may be accessed on the Electronic Procurement Services (LPSE) portal. Tender data obtained was from the Ministry of Transportation's LPSE website which consisted of 387 data on docking tenders and new shipbuilding projects. The selected data is based on the entire input data of ship project proposals related to the tender for auction ship docking projects. In all, this includes 151 data tender initiatives for docking ships.

The next step is the sample filtration. The sample filtration is based on the criteria in the problem limitations, i.e. the tender for the docking ship project done between 2021 and 2023, with a minimum of two contractor businesses. The project shall have an HPS (Harga Pokok Satuan) or unit cost price of not less than IDR 2,000,000,000, and shall use lump summit, unit price, and mixed contract types using the lowest price technique in an elimination procedure. This result shows that 22 docking ships are providing samples from the tender held between 2021 and 2023, with a total of 27 shipyard enterprises participating in the bidding procedure.

Data Analysis

1.) Research Data Processing

Upon acquisition of the requisite data, it is processed and analysed via established methodologies. The initial phase entails data processing by statistical methodologies employing multi-normal distribution, and single-normal distribution. The initial step is to transform the acquired sample into a ratio organized from smallest to greatest. The last stage involves calculating the average (mean), standard deviation, and variance to be utilised in the three statistical methods based on previously established beginning ratios. The multi-normal and single-normal distribution methods utilize a cumulative normal distribution Z table. The outcomes derived from this initial phase are the winning odds for each participant.

The subsequent phase, after ascertaining the winning odds for each contender, entails computing the highest projected profit and establishing the optimal markup value according to two bidding strategy models: the Friedman model, the Gates model. A graph is subsequently constructed to compare the anticipated profit value with the markup value produced by each bidding model.

2.) Data Evaluation

The best markup value is subsequently evaluated against the lowest bid price supplied by the contractors, determining if it is lower (indicating a win) or higher (indicating a loss). The test results are derived by modelling the markup value calculated against the projected contract cost and subsequently comparing it with the lowest quote from the successful bidder. The selected data for testing comprises the latest auction information from all data utilized in this study, positing that the most recent data most accurately represents the prevailing auction circumstances.

3.) Conclusions and Recommendations

The results aim to ascertain the success rate and anticipated profit value for the tested bid price values utilizing the relevant models. Recommendations are provided concerning the suitable bidding model to adopt based on the company's anticipated circumstances from a tender.

Findings

The data conditions were less than optimal for testing due to the large number of companies that were obtained. Consequently, the calculation that was conducted will be written exclusively for further articles but the results of optimum markup value for all companies is asserted in a sub chapter. Consequently, a single company, which is Company A, was chosen to represent the testing of each company that participated in the tender, as it satisfied the research requirements and limitations.

Finding 1 about figures

a) Multi Normal Distribution

The method begins by calculating the multi-normal distribution probability (Pmdn) of each bid from Company A using the standard deviation of the lowest average bid. The next step is to calculate the P Win value using equation as follows in the example below:

R = 1 + Markup
= 1 + 25%
= 1.25
P Win = P (Bo<Bi) x P (Bo<B) x . . . . . x P (Bo<Bn)
= Pmdn1 x Pmdn2 x Pmdn3 x Pmdn4
= 0.00003 x 0.47959 x 0.48605 x 0.13193
= 0.0000009

Continue by calculating the expected profit value using equation as follows:

E (P) = Markup x P Win
= 25% x 0.0000009

= 0.00002

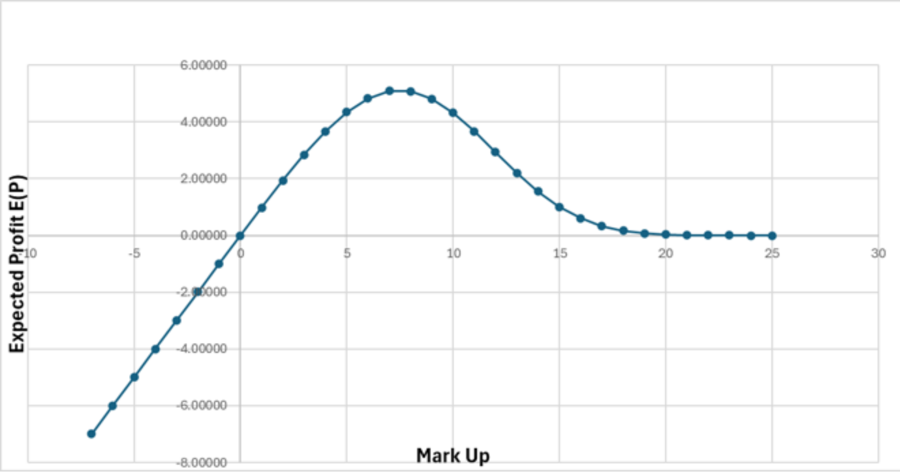
The results of calculating the probability of winning and expected profit with multi normal distribution for Friedman's model for Company A can be seen in Table 1.

Table 1: Winning Probability and Expected Profits of Company A on Friedman Model Using Multi Normal Distribution (Author's Work)

Mark-Up(%)	R	P Win	E (P)
25	1.25	0.0000009	0.00002
24	1.24	0.00001	0.00013
23	1.23	0.00003	0.00066
22	1.22	0.00012	0.00273
21	1.21	0.00045	0.00947
20	1.2	0.00141	0.02812
19	1.19	0.00381	0.07245
18	1.18	0.00912	0.16420
17	1.17	0.01952	0.33183
16	1.16	0.03784	0.60544
15	1.15	0.06722	1.00832
14	1.14	0.11052	1.54733
13	1.13	0.16961	2.20488
12	1.12	0.24464	2.93562
11	1.11	0.33363	3.66994
10	1.1	0.43243	4.32434
9	1.09	0.53521	4.81686
8	1.08	0.63540	5.08316
7	1.07	0.72693	5.08853
6	1.06	0.80530	4.83180
5	1.05	0.86816	4.34079
4	1.04	0.91538	3.66154
3	1.03	0.94862	2.84585
2	1.02	0.97052	1.94104
1	1.01	0.98404	0.98404
0	1	0.99185	0.00000
-1	0.99	0.99608	-0.99608
-2	0.98	0.99823	-1.99646
-3	0.97	0.99925	-2.99774
-4	0.96	0.99970	-3.99879
-5	0.95	0.99989	-4.99943
-6	0.94	0.99996	-5.99976
-7	0.93	0.99999	-6.99991

According to Table 1, the optimum mark-upvalue is 7% with an expected profit of 5.08%. The corelation between expected profit and mark up on the multi normal distribution for the Friedman model can be seen in Figure 2. Based on Figure 2, it is not recommended if Company A applies a mark-up below 0% because it will cause losses to the company. And it is also not recommended if you apply a mark-up above 15% because the expected profit generated is exceedingly small, even close to 0%.

Figure 2: Correlations Between mark- Up and Expected Profits on Friedman Model Using Multi Normal Distribution (Author's Work)



b) Single Normal Distribution

The single normal distribution results are applied to the Friedman Model using Equation of the "winning probability for unknown competitors". This is because only the number of competitors is known, while their identities are unknown. Below is an example calculation at a 20% markup:

R = 1 + Markup

= 1 + 20%

= 1.2

The following is an example calculation using the equation:

P(Co Win /Bo) = P (Bo < Ba)^n

= (0.59119)20

P Win = 0.00003

The results of calculating the winning probability and expected profit with Single normal distribution for Friedman's model for Company A can be seen in Table 2.

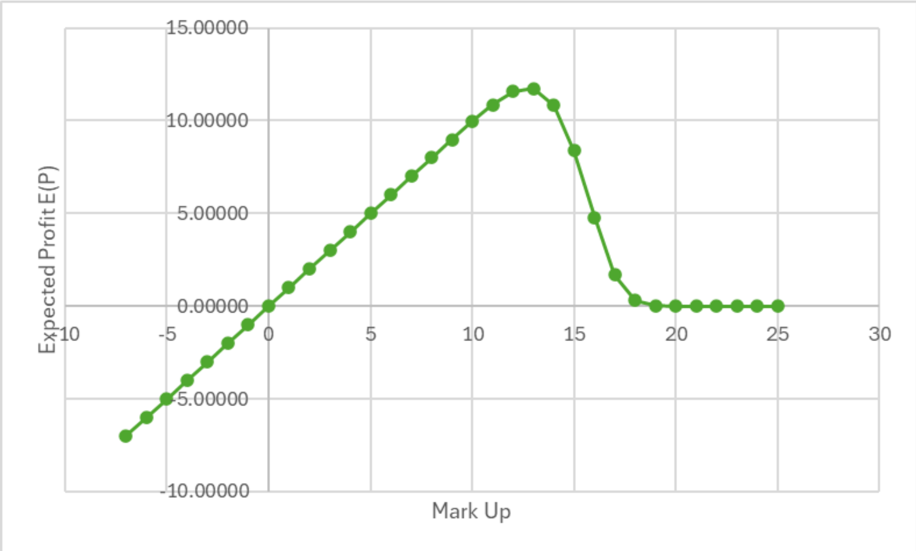
Table 2: Winning Probability and Expected Profits of Company A on Friedman Model Using Single Normal Distribution (Author's Work)

Mark-Up(%)	R	P Win	E (P)
25	1.25	0.00000	0.00000
24	1.24	0.00000	0.00000
23	1.23	0.00000	0.00000
22	1.22	0.00000	0.00000
21	1.21	0.00000	0.00000
20	1.2	0.00003	0.00054
19	1.19	0.00118	0.02237
18	1.18	0.01689	0.30410
17	1.17	0.09942	1.69016
16	1.16	0.29807	4.76914
15	1.15	0.55783	8.36750
14	1.14	0.77328	10.82589
13	1.13	0.90220	11.72862
12	1.12	0.96340	11.56074
11	1.11	0.98787	10.86661
10	1.1	0.99641	9.96409
9	1.09	0.99905	8.99141
8	1.08	0.99977	7.99818
7	1.07	0.99995	6.99966
6	1.06	0.99999	5.99994
5	1.05	1.00000	4.99999
4	1.04	1.00000	4.00000
3	1.03	1.00000	3.00000

2	1.02	1.00000	2.00000
1	1.01	1.00000	1.00000
0	1	1.00000	0.00000
-1	0.99	1.00000	-1.00000
-2	0.98	1.00000	-2.00000
-3	0.97	1.00000	-3.00000
-4	0.96	1.00000	-4.00000
-5	0.95	1.00000	-5.00000
-6	0.94	1.00000	-6.00000
-7	0.93	1.00000	-7.00000

Table 2 stated that the optimum mark-up value is around 13 % with an expected profit of 11.72%. The corelation between expected profit and mark up on the single normal distribution for the Friedman model can be seen in Figure 3. Based on Figure 3, it is not recommended if Company A applies a mark-up below 0% because it will cause losses to the company. And it is also not recommended if you apply a mark-up above 17% because the expected profit generated is getting smaller, even close to 0%.

Figure 3: Correlations Between mark- Up and Expected Profits on Friedman Model Using Single Normal Distribution (Author's Work)



Gates Model

a) Multi Normal Distribution

The process begins by calculating the probability using a statistical distribution, similar to the Friedman model. In this case, a multi-normal distribution (P mdn) is used for each bid from Company A based on the standard deviation and mean results. The calculation then continues by determining the P-Win value using the following equation that shown using the example of markup 25%:

$$\text{P Win} = \frac{1}{1+\sum_{i=0}^{n}\frac{1-P(Bo<Bi)}{P(Bo<Bi)}} \text{ Or } \frac{1}{1+\sum_{i=0}^{n}\frac{1-(P\ mnd)}{(P\ mnd)}}$$

$$= \frac{1}{1+(34{,}353.10345 + 1.08512 + 1.05742 + 6.57998)}$$

$$= \frac{1}{1+(34{,}361.82597)}$$

$$= 0.00003$$

The results calculating the winning probability and expected profit with multi normal distribution for Gate's model for Company A can be seen in Table 3.

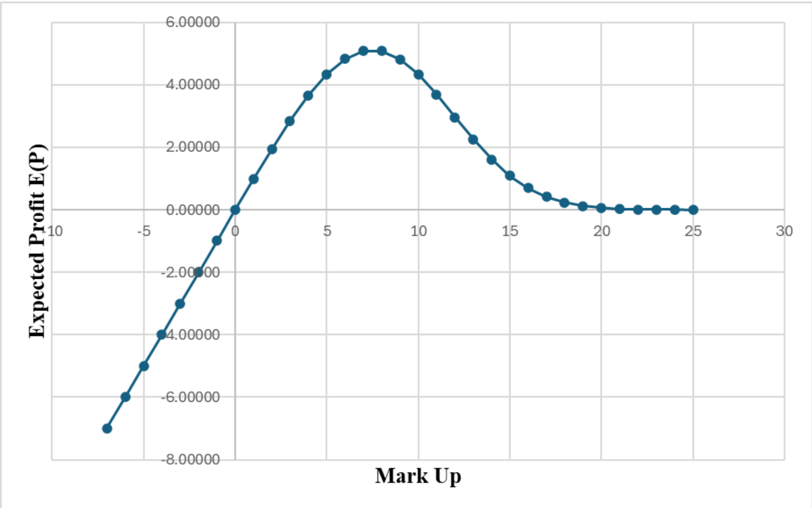
Table 3: Winning Probability and Expected Profits of Company A on Gates Model Using Multi Normal Distribution (Author's Work)

Mark-Up(%)	R	P Win	E(P)
25	1.25	0.00003	0.00073
24	1.24	0.00008	0.00201

23	1.23	0.00023	0.00522
22	1.22	0.00058	0.01271
21	1.21	0.00138	0.02900
20	1.2	0.00310	0.06209
19	1.19	0.00657	0.12477
18	1.18	0.01308	0.23545
17	1.17	0.02456	0.41756
16	1.16	0.04353	0.69647
15	1.15	0.07290	1.09349
14	1.14	0.11552	1.61731
13	1.13	0.17347	2.25517
12	1.12	0.24726	2.96709
11	1.11	0.33518	3.68699
10	1.1	0.43323	4.33231
9	1.09	0.53556	4.82005
8	1.08	0.63553	5.08426
7	1.07	0.72698	5.08885
6	1.06	0.80531	4.83188
5	1.05	0.86816	4.34081
4	1.04	0.91538	3.66154
3	1.03	0.94862	2.84585
2	1.02	0.97052	1.94104
1	1.01	0.98404	0.98404
0	1	0.99185	0.00000
-1	0.99	0.99608	-0.99608
-2	0.98	0.99823	-1.99646
-3	0.97	0.99925	-2.99774
-4	0.96	0.99970	-3.99879
-5	0.95	0.99989	-4.99943
-6	0.94	0.99996	-5.99976

Table 3 indicates that the ideal mark-up value is around 7%, yielding an expected profit of 5.08%. The correlation between anticipated profit and markup on the multi normal distribution for the Gates model is seen in Figure 4. According to Figure 4, it is inadvisable for firm A to implement a mark-up below 0%, since it will result in financial losses for the firm. Moreover, it is inadvisable to impose a mark-up above 15%, as the anticipated profit diminishes significantly, approaching 0%.

Figure 4: Correlations Between mark- Up and Expected Profits on Gates Model Using Multi Normal Distribution (Author's Work)



b) Single Normal Distribution

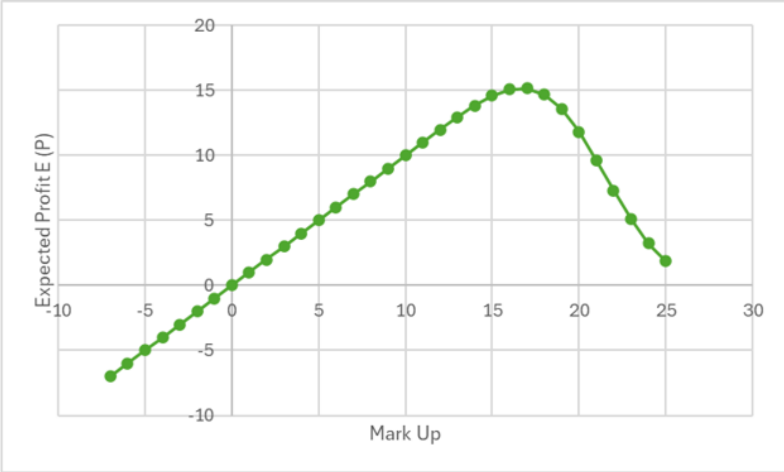
In this model, a single normal distribution uses the Bid/Cost value, which are the mean, standard deviation, and variance of the highest bid ratios for each tender. Next step is to calculate the probability of winning. The results are shown in Table 4.

Table 4 Winning Probability and Expected Profits of Company A on Gates Model Using Single Normal Distribution (Author's Work)

Mark-Up(%)	R	P.Win	E (P)
25	1.25	0.075208413	1.880210323
24	1.24	0.134726006	3.233424156
23	1.23	0.220474978	5.070924503
22	1.22	0.331108354	7.284383799
21	1.21	0.458934108	9.63761626
20	1.2	0.591193409	11.82386818
19	1.19	0.713742454	13.56110662
18	1.18	0.815430311	14.67774559
17	1.17	0.890992197	15.14686735
16	1.16	0.94127385	15.06038161
15	1.15	0.971236993	14.56855489
14	1.14	0.987226449	13.82117029
13	1.13	0.994867367	12.93327577
12	1.12	0.998137153	11.97764583
11	1.11	0.999390152	10.99329168
10	1.1	0.999820121	9.998201207
9	1.09	0.999952241	8.99957017
8	1.08	0.999988595	7.999908758
7	1.07	0.999997552	6.999982862
6	1.06	0.999999528	5.999997167
5	1.05	0.999999918	4.999999591
4	1.04	0.999999987	3.999999949
3	1.03	0.999999998	2.999999995
2	1.02	1	2
1	1.01	1	1
0	1	1	0
-1	0.99	1	-1
-2	0.98	1	-2
-3	0.97	1	-3
-4	0.96	1	-4
-5	0.95	1	-5
-6	0.94	1	-6
-7	0.93	1	-7

Table 4 demonstrates that the optimal mark-up value is around 17%, resulting in an expected profit of 15.14%. Figure 4 illustrates the association between projected profit and markup within the single normal distribution of the Gates model. Figure 5 indicates that it is unwise for firm A to adopt a mark-up below 0%, as this would lead to financial losses for the company. Furthermore, imposing a mark-up above 25% is ill-advised, since the projected profit substantially declines, nearing 1%.

Figure 5: Correlations Between mark- Up and Expected Profits on Gates Model Using Single Normal Distribution (Author's Work)



Mark-Up optimum for all company (A-AA)

Referred to Table 5 The Friedman model produces the smallest optimum markup of the two statistical approaches used, with a range starting from 5% to 20% for multi-normal distribution and 12% to 13% for single-normal distribution. While Gates produces more mark-up value for multi-normal distribution, the range starting from 6% to 20%. For single-normal distribution, stable at 17%.

Table 5: Mark Up Optimum of each Company

Distribution Types	MODEL	Optimum Mark-up for Each Company (%)										
		A	B	C	D	E	F	G	H	I	J	K
Multi Normal Distribution	Friedman	7	17	7	17	8	15	17	9	11	12	17
	Gates	7	17	8	17	8	16	17	9	12	12	17
Single Normal Distribution	Friedman	13	12	13	12	13	13	13	13	13	13	13
	Gates	17	17	17	17	17	17	17	17	17	17	17
Distribution Types	**MODEL**	Optimum Mark-up for Each Company (%)										
		L	M	N	O	P	Q	R	S	T	U	V
Multi Normal Distribution	Friedman	17	11	19	15	5	14	6	9	17	16	16
	Gates	17	11	19	15	6	14	6	9	17	16	16
Single Normal Distribution	Friedman	13	13	13	13	13	13	13	13	12	13	12
	Gates	17	17	17	17	17	17	17	17	17	17	17
Distribution Types	**MODEL**	Optimum Mark-up for Each Company (%)										
		W	X	Y	Z	AA						
Multi Normal Distribution	Friedman	20	19	17	19	13						
	Gates	20	19	17	19	13						
Single Normal Distribution	Friedman	12	12	12	12	13						
	Gates	17	17	17	17	17						

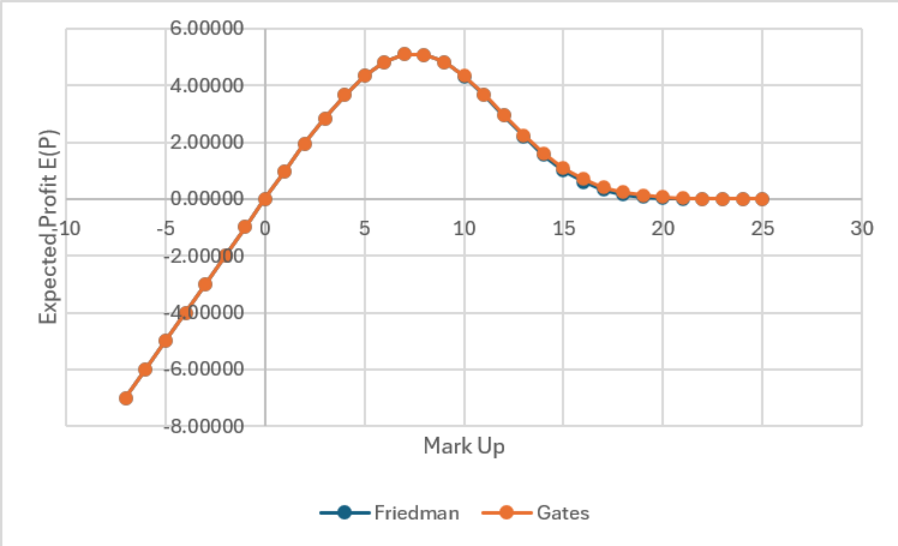
Relationship of Expected Profit and Mark-up for Each Model

The comparison analyses Company A representing the whole company in the sample.

a) Multi Normal Distribution

The charts on Figure 6 depicts the correlation between anticipated profit and mark-up according to the Friedman and Gates models. The expected profit adheres to a regular distribution pattern: it escalates with an increase in mark-up, peaks at around 7%–8% generating expected profit in 5% range and thereafter declines as the mark-up continues to climb. Implementing a mark-up below 0% is inadvisable as it leads to negative projected profit, indicating potential financial losses for the organization. Nonetheless, implementing an excessively high mark-up is inadvisable, since the anticipated profit diminishes significantly and nears 0%, particularly when the mark-up surpasses around 18%–20%. The Friedman and Gates models exhibit very identical trends in the graph. The curves are closely aligned, suggesting that both models yield comparable predicted profit outcomes. Consequently, the optimal mark-up is situated at the apex of the curve, where the corporation may get the most anticipated profit while preserving a competitive offer.

Figure 6: The Relationship Between Expected Profit and Mark Up on Multi Normal Distribution

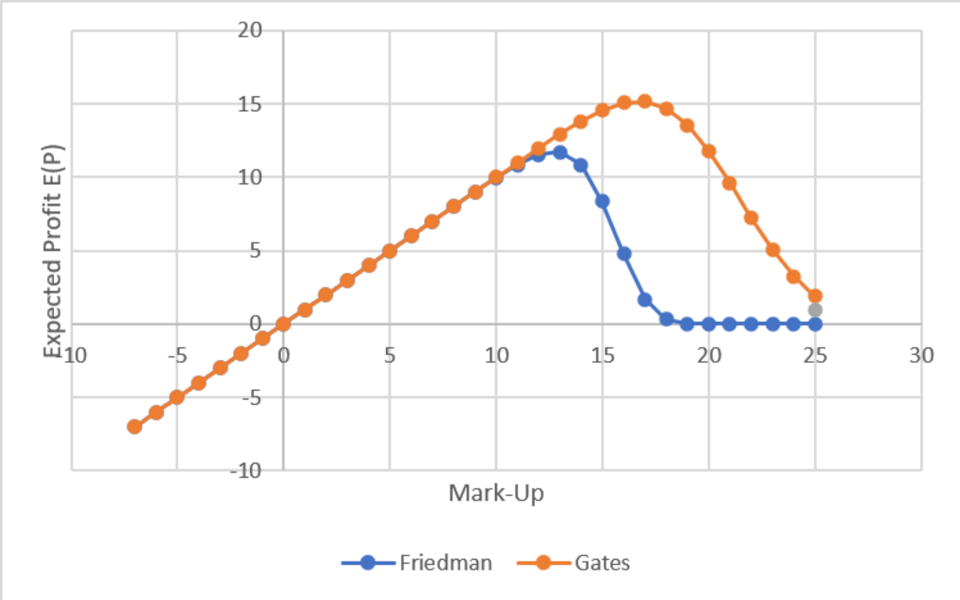


b) Single Normal Distribution

The illustration on Figure 7 depicts the correlation between anticipated profit and mark-up for the Friedman and Gates models. The anticipated profit escalates with an increase in mark-up, attains an optimal level, and then declines when the mark-up is excessively high. Implementing a mark-up below 0% is inadvisable, as both models indicate a negative projected profit, suggesting potential losses for the firm. In the Friedman Model, the anticipated profit peaks at around a 13% markup, yielding an expected profit of nearly 12. Subsequently, the profit declines precipitously and approaches near-zero following an approximate 18% mark-up.

Simultaneously, the Gates Model yields a superior anticipated profit in comparison to the Friedman Model. The optimal anticipated profit is achieved at a mark-up of roughly 16%–17%, yielding an expected profit of around 15%. Despite the anticipated profit diminishing beyond this juncture, the Gates Model continues to indicate a positive value up to the maximum mark-up range. Consequently, the Gates Model yields a superior optimal mark-up and anticipated profit, whereas the Friedman Model adopts a more conservative approach, resulting in a diminished optimum mark-up. The graph indicates that employing an extremely high markup is inadvisable, as it diminishes the likelihood of achieving optimal predicted profit.

Figure 7: The Relationship Between Expected Profit and Mark Up on Singlei Normal Distribution



Discussion

Previous research on tendering strategy has demonstrated that the determination of markup is a critical factor in the delicate balance between the likelihood of obtaining a tender and the realization of anticipated profits. Contractors must meticulously establish the markup value in competitive project-based work, as it has a direct impact on both the competitiveness of their bids and the potential for profit. This discussion is based on the findings of Maharani et al. (2021), Narendra's (2014), Willian, E. (2022), and Kasa and Herzanita (2021), which elucidate the correlation between markup, bidding models, winning probability, and expected profit.

This discourse pertains to the research inquiry regarding the tendering model that generates the most competitive optimal markup and anticipated profit in ship mooring tenders. The Friedman and Gates models are compared in the analysis using single-normal and multi-normal distribution approaches. This comparison is crucial because contractors participating in ship mooring tenders require a tendering strategy that can enhance their likelihood of success while simultaneously ensuring an acceptable level of anticipated profit.

The Friedman model, which employs a multi-normal distribution, generates the lowest optimum markup value among the models and approaches that were evaluated, as indicated by the results. The Friedman model, which employs multi-normal distribution, generates optimal markup values for each organization that range from 5% to 20%, as indicated in Table 5. In contrast, the Friedman model employs a single-normal distribution to generate optimal markup values of approximately 12% to 13%. The Gates model, on the other hand, employs a multi-normal distribution to generate values between 6% and 20%. The Gates model, on the other hand, employs a single-normal distribution to generate a consistent value of 17%.

The Friedman model employing a multi-normal distribution appears to be the most competitive strategy, as it generates the lowest optimum markup value. This is a significant discovery. A more competitive quote price can be offered by contractors when the optimum markup is reduced, particularly in tenders that employ a lowest-price evaluation system. Compared to the Gates model, the Friedman model is more conservative in this context, as it prioritizes a less bid price to enhance the likelihood of obtaining the tender.

However, the Gates Model is not always the most competitive strategy for obtaining tenders, even though it generally generates a higher optimum markup and anticipated profit. This is an unexpected outcome. The Friedman Model achieves its anticipated profit apex at approximately a 13% markup in the single-normal distribution approach, resulting in an anticipated profit of nearly 12%. Conversely, the Gates Model achieves its maximum profit at a markup of approximately 16%–17%, with an anticipated profit of approximately 15%. This suggests that the Gates Model may be more appealing to contractors who are interested in achieving a higher expected profit. However, it may also present a higher risk of losing due to the decreased competitiveness of the bid price.

The results corroborate prior research that indicates the Friedman model with a multi-normal distribution generates reduced optimum markup values. This is in accordance with three previous studies: Maharani et al. (2021) determined an optimal markup of 4% for the Friedman model using a multi-normal distribution, which is lower than the Ackoff and Sasieni model, which generated a 9% mark-up rate. Additionally, Narendra's (2014) research yielded the Friedman model's minimal annotation values for multinormal distributions, which ranged from 8% to 21%. Furthermore, the Friedman model with multi-normal distributions generated the lowest markup value, with a value of 10% for multi-normal distribution, according to the study conducted by Willian, E. (2022). This value was lower than that of the single-normal distribution, which generated 20%.

Nevertheless, the results also demonstrate a distinct pattern from those of studies that prioritize the lowest markup as the primary indicator of a suitable tendering strategy. In comparison to the Friedman Model, the Gates Model typically generates a higher optimal mark-up and expected profit in this investigation. This outcome is consistent with previously conducted research by Maharani et al. (2021), which suggests that the Friedman model generates a reduced expected profit value, specifically between 0.23% and 16.03%. In contrast, the Ackoff and Sasieni model generates an expected profit value ranging from 2.60% to 20.80%. In contrast to the Gates model, which generates profits between 19.8% and 30%, the Friedman model yields a reduced expected profit, ranging from 7.1% to 29.9%, according to research conducted by Willian, E. (2022). Thus, while the Friedman model is more competitive in terms of a lower markup, the Gates model can be regarded as more robust in terms of expected profit.

The inverse relationship between the probability of winning and the markup value can account for the decrease in expected profit that occurs after the optimum markup point. The Friedman and Gates models exhibit a similar pattern in the multinormal distribution, with an anticipated profit peaking at a mark-up of approximately 7%–8%, resulting in an expected profit of approximately 5%. As the markup increases, the anticipated profit decreases gradually beyond this threshold. This is because a higher markup may increase the prospective profit per project, but it also decreases the likelihood of obtaining the tender. This condition is consistent with Kasa and Herzanita (2021), who asserted that markup is contingent upon the company's objectives, particularly profit maximization. While a substantial markup may increase profit margins, it may also decrease the likelihood of securing a contract. Conversely, a low markup may increase the likelihood of success while resulting in reduced earnings.

The results of these findings should be interpreted with caution, as they are contingent upon the tendering model assumptions, the statistical distribution approach, and the selected tender data that were employed in the study. If the anticipated profit and markup are compared to a larger dataset, different tender periods, different project types, or different levels of contractor competition, the results may differ. Given these results, it is possible to formulate a general hypothesis: in intensely competitive lowest-price tenders, a more conservative markup strategy may increase the likelihood of success, whereas a higher markup strategy may increase expected profit but decrease competitiveness.

These findings suggest that shipyard contractors should not solely focus on achieving high profits when determining proposal prices; they should also take into account historical tender patterns and the probability of winning. When contractors prioritize competitiveness and tender-winning probability, the Friedman model employing a multi-normal distribution can serve as a reference. In the interim, the Gates model may be considered when contractors are prepared to assume greater risk in exchange for a greater anticipated profit. It is recommended that future research be conducted to enhance the generalizability and accuracy of bid pricing strategy recommendations by comparing various categories of maritime projects, incorporating more shipyard companies, utilizing larger tender datasets, and applying additional tendering models.

Conclusion

The present study had the objective to determine and contrast the optimal mark-up values and expected profits in Indonesian ship docking tenders by employing the Friedman and Gates bidding models. Using historical tender data from ship docking projects completed during the 2021–2023 period on the LPSE page of the Ministry of Transportation, the research was conducted to determine the most appropriate bid pricing strategy for contractors. By pursuing this objective, the research explored the extent to which contractors can establish competitive quote prices while simultaneously contemplating profitability by utilizing various statistical distribution methods and tendering models.

The primary results indicate that the Friedman model, which employs a multi-normal distribution, generates the lowest optimum mark-up value and is the most effective approach to securing tenders. This model is more cautious than the Gates model in that it generates a bid price that is more competitive. The results also indicate that the Gates model typically generates a higher expected profit and optimum mark-up than the Friedman model. Nevertheless, the likelihood of obtaining the tender is diminished by a higher mark-up, necessitating that contractors reconcile their profit expectations with their likelihood of procuring the project.

The results also suggest that the expected profit increases until it reaches the optimal mark-up point, after which it decreases. This implies that contractors may not always benefit from implementing an extremely high markup, as it may decrease their likelihood of obtaining the tender. For contractors who prioritize competitive proposal pricing, the Friedman model can serve as a reference in this study. Conversely, the Gates model can be employed by contractors who are prepared to pursue higher profit potential at the risk of losing the tender.

The field of knowledge is affected by the fact that tendering strategy models can be implemented in maritime-based projects, such as ship mooring tenders, in addition to general construction projects. This study contributes to the academic discourse by demonstrating the potential of the Friedman and Gates models, which are bolstered by single-normal and multi-normal distribution methodologies, to assess the optimal mark-up and anticipated profit in the Indonesian ship repair sector. Consequently, the investigation broadens the scope of tendering model analysis to encompass a more precise maritime procurement context.

The importance of this investigation is derived from its impact on both theory and practice. This research offers theoretical evidence that various bidding models can generate varying levels of expected profit and competitiveness. From a practical standpoint, the findings can assist shipyard contractors in utilizing historical tender data as a foundation for preparing proposal prices, reducing pricing uncertainty, and enhancing decision-making in competitive e-procurement tenders.

Nevertheless, it is imperative to acknowledge the numerous constraints of this investigation. The findings may not entirely represent all ship repair or shipbuilding tenders in Indonesia, as the analysis was restricted to ship mooring tender data from the LPSE Ministry of Transportation during the 2021–2023 period. The Friedman and Gates models with single-normal and multi-normal distribution approaches were also the sole focus of the study. The findings continue to make a valuable contribution by providing a structured comparison of proposal pricing strategies for ship mooring tender cases, despite these limitations.

Before submitting bid prices, shipyard contractors are advised to consult historical tender data and tendering models for the purposes of practice and policy. Contractors who prioritize winning probability may implement the Friedman model with a multi-normal distribution as a more competitive tendering strategy. Meanwhile, contractors who are interested in achieving a higher expected profit may want to consider the Gates model; however, they should conduct a thorough evaluation of the risk of losing the tender. Contractors, researchers, and policymakers can enhance their tendering strategies and foster healthier competition in Indonesia's maritime industry by enhancing the transparency and accessibility of e-procurement tender data from a policy perspective.

An extended observation period, a larger dataset, and additional bidding strategy models are recommended for future research. Subsequent research may compare the Friedman and Gates models with other models, such as the Ackoff–Sasieni model or employ alternative statistical distribution methodologies to enhance the precision of optimal mark-up estimation. To determine whether the results are consistent across various project types, future research could also investigate other maritime project categories, including new shipbuilding, ship maintenance, or offshore facility projects.

Ethics approval

Not required. This study used secondary tender data obtained from the Electronic Procurement Service (LPSE) of the Ministry of Transportation of the Republic of Indonesia and did not involve human participants, personal data, or animal subjects. Therefore, ethical approval and informed consent were not required.

Acknowledgments

The authors would like to express their gratitude to all parties who provided support, guidance, and assistance during the preparation of this research. The authors also appreciate the availability of procurement data from the Electronic Procurement Service (LPSE) of the Ministry of Transportation of the Republic of Indonesia, which supported the completion of this study.

Competing interests

All the authors declare that there are no conflicts of interest.

Funding

This study received no external funding.

Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

If This study used artificial intelligence (AI) tools for manuscript writing support. AI-based language models, such as Quillbot, were used for language refinement, improving grammar, sentence structure, readability, content summarization, and technical writing assistance. No AI tools were used for data collection, data analysis, statistical calculation, or interpretation of research results.

We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

How to cite

Baharudin, M. F., Hardiyanti, F., & Maharani, A. (2026). Comparative Analysis of Bid Pricing Strategies in E-Procurement Ship Docking Tenders in Indonesia Using the Friedman and Gates Models. *Journal of Society Innovation and Development*, *8*(1), 421–441. https://doi.org/10.63924/jsid.v8i1.300

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Appendix

Table 6: Lists of The Company as Data Sample

Kode	Perusahaan
A	PT. YESTOYA MARINE SERVICES
B	PT. YASA WAHANA TIRTA SAMUDERA
C	CV. ALVARO TECHNICAL MARINE
D	CV EVADA JAYA
E	CV. INTI SARANA
F	PT TEKNIKA INDO MARITIM
G	PT. DUMAS TANJUNG PERAK SHIPYARD
H	PT.SINERGI INDO UTAMA
I	CV. PANTNG MUNDUR
J	PT. DOK BAHARI NUSANTARA -
K	PT. TECHNO AZA MARINE
L	PT. ADILUHUNG SARANASEGARA INDONESIA
M	PT. DUKUH RAYA SHIPYARD AND ENGINEERING
N	MULTI OCEAN SHIPYARD
O	PT. BAYUBAHARI SANTOSA
P	PT.AQUILA JAYA MARINA
Q	PT DAYA RADAR UTAMA
R	CV. MUSTIKA JAYA BAHARI
S	CV.DEKA CIPTA SARANA
T	PT. SUBUR SAKTI
U	HILMA YADA
V	PT WIRA SENTOSA ABADI
W	PT. GALANGAN KAPAL WAYATA KENTJANA
X	PT.NUSANTARA PRIMA TEKNOLOGI
Y	PT. BANDAR ABADI
Z	CV BHISMA PRIMA MEDIA
AA	PT DEWA RUCI AGUNG
Total	27

Table 7 Data of Company's Bidding Offer

No	Kode	Instansi	HPS	Nama Paket	Tahun	PT. YESTOYA MARINE SERVICES	PT. YASA WAHANA TIRTA SAMUDERA	CV. ALVARO TECHNICAL MARINE	CV.EVADA JAYA	CV. INTI SARANA	PT TEKNIKA INDO MARITIM	PT. DUMAS TANJUNGPERAK SHIPYARD	PT.SINERGI INDO UTAMA	CV. PANTANG MUNDUR	PT. DOK BAHARI NUSANTARA -	PT. TECHNO AZA MARINE	PT. ADILUHUNG SARANASEGARA INDONESIA	PT. DUKUH RAYA SHIPYARD AND ENGINEERING	MULTI OCEAN SHIPYARD	PT. BAYUBAHARI SANTOSA
1	82123114	Kementerian Perhubungan	Rp2,641,515,250	DOCKING KAPAL LATIH MH.THAMRIN	2021	Rp2,310,828,850	Rp 2,564,549,900													
2	81155114	Kementerian Perhubungan	Rp2,474,365,000	DOCKING KN. KALAWAI P.117	2021			Rp2,367,838,000	Rp 2,415,834,850											
3	81711114	Kementerian Perhubungan	Rp3,784,495,000	PEMELIHARAAN/DOCKING KAPAL NEGARA KENAVIGASIAN KN.MAHKOTA	2021	Rp3,778,462,193		Rp3,476,000,000		Rp 3,342,489,272	Rp3,718,998,525	Rp 3,784,369,699								
4	79083114	Kementerian Perhubungan	Rp2,400,345,200	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 13	2021						Rp2,340,921,825		Rp2,159,742,200	Rp2,218,537,200	Rp2,370,170,000					
5	78372114	Kementerian Perhubungan	Rp2,245,954,150	DOCKING KAPAL TERNAK KM. CAMARA NUSANTARA 6	2021											Rp2,211,625,900	Rp 2,215,763,000			
6	78371114	Kementerian Perhubungan	Rp2,324,054,150	DOCKING KAPAL TERNAK KM. CAMARA NUSANTARA 4	2021						Rp2,287,525,900	Rp2,307,738,157								
7	78370114	Kementerian Perhubungan	Rp2,352,654,150	DOCKING KAPAL TERNAK KM. CAMARA NUSANTARA 3	2021			Rp2,108,700,000				Rp2,335,913,061								
8	77736114	Kementerian Perhubungan	Rp2,645,858,600	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 11	2021											Rp2,626,231,025	Rp2,610,619,000	Rp2,408,865,250		
9	77613114	Kementerian Perhubungan	Rp2,524,858,600	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 2	2021														Rp2,500,000,000	Rp2,520,715,175
10	78028114	Kementerian Perhubungan	Rp5,160,798,720	DOCKING KAPAL PERINTIS KM. SABUK NUSANTARA 33 (GT 1200), K-PENGGANTI	2021									Rp4,896,648,350	Rp4,815,800,000					Rp4,948,467,150
11	76434114	Kementerian Perhubungan	Rp5,293,113,980	DOCKING KAPAL PERINTIS KM. SABUK NUSANTARA 32 (GT 1200), PANGKALAN SAUMLAKI	2021						Rp5,274,084,200				Rp5,005,000,000					
12	88866945114	Kementerian Perhubungan	Rp2,595,576,270	PEMELIHARAAN KAPAL NEGARA KENAVIGASIAN (KN DEBRILL)	2022			Rp2,319,900,000												
13	92615114	Kementerian Perhubungan	Rp2,821,525,850	Docking Kapal Latih POLITEKNIK PELAYARAN BAROMBONG	2023															
14	92611114	Kementerian Perhubungan	Rp4,481,903,610	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 3	2023								Rp4,302,627,454							
15	92533114	Kementerian Perhubungan	Rp4,735,381,963	DOCKING KAPAL LATIH BUNG TOMO POLITEKNIK PELAYARAN SURABAYA 2023	2023															
16	92309114	Kementerian Perhubungan	Rp2,211,789,200	DOCKING KN. TRISULA - P.111	2023	Rp2,209,379,521														
17	92523114	Kementerian Perhubungan	Rp2,214,195,500	DOCKING KN. ALUGARA - P.114	2023	Rp2,137,150,710														
18	91127114	Kementerian Perhubungan	Rp2,938,000,000	DOCKING KN.KALIMASADHA-P.115	2023			Rp2,789,396,700												
19	90554114	Kementerian Perhubungan	Rp3,899,358,960	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 9	2023															
20	90673114	Kementerian Perhubungan	Rp3,996,239,760	DOCKING KAPAL TERNAK KM. CAMARA NUSANTARA 3	2023			Rp3,885,000,000					Rp3,953,686,245							
21	92611114	Kementerian Perhubungan	Rp4,481,903,610	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 3	2023								Rp4,302,627,454							
22	92696114	Kementerian Perhubungan	Rp4,499,985,510	DOCKING KAPAL TOL LAUT KM. KENDHAGA NUSANTARA 11	2023								Rp4,233,424,670							