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Concentration of Bid Prices Just Above the Standard Minimum Price in Public Construction Works

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Abstract: In Japan, contract offices are mandated to set threshold prices for public works. A threshold price is the upper limit of the bid price, and a contractor who exceeds this threshold is disqualified. Furthermore, based on the threshold price, a minimum price is set as a price requiring investigation before acceptance. In recent years, bids and contracts for public works have generally had bid prices concentrated slightly above the standard minimum for investigation. It has been pointed out that this tendency is detrimental in terms of the motivation of engineers and social costs. In this study, we confirm that this tendency was alleviated and that the level of the winning bidder's technical evaluation score was feasible at the same time. In addition, we obtained quantitative findings on variables that affect both above. Furthermore, although it is impossible to achieve a perfect balance between alleviating the tendency of prices to concentrate slightly above the standard minimum for investigation and sufficient technical evaluation scores, elements necessary to improve the overall situation were quantitatively identified.

Keywords: Public procurement; Quality-and-cost-based selection method; Standard minimum price for investigation.

1. Introduction

1.1 Background

Public procurement in Japan is based on the planned price system stipulated in the Accounting Law enacted in 1889. Article 777 of "Accounting Regulations (Meiji Accounting Regulations)" stipulates the procedures necessary for the enforcement of the Accounting Law, stating that the threshold price is the upper limit of the contract amount in the case of "buying" and the lower limit of the contract amount in the case of "selling". In 1920, the Ministry of the Interior established the "Road Construction Execution Ordinance" with Ministry of Interior Ordinance No. 36. A major feature of this edict is that it sets a "minimum threshold price" on winning bids. Kinoshita explains this policy as follows: "bidders who offer their services too cheaply often raise quality concerns, and therefore contracting with the bidder who offers the lowest price is not always desirable. Thus, there was an idea to decide the contract bidder with an emphasis on the ability to perform the construction work" [1].

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has set the "Low bid price survey standard (stipulated in Article 85 of Budget Settlement and Accounting Ordinance)" as the standard for "when it is recognized that there is a risk that the contents of the contract will not be fulfilled in accordance with the contents of the contract". In the "Act on Promotion of Bidding for Public Works and Appropriate Contracts (Act No. 127 of 2000)", the prevention of dumping orders is specified as a basic matter for optimization of bidding and contracts of public works. Furthermore, in the "Guidelines for Measures to Optimize Bidding for Public Works and Contracts" (Cabinet decision on September 30, 2014), the reference price of the standard minimum price for investigation is to be reviewed as appropriate from the viewpoint of preventing dumping orders [2].

On the other hand, the "Act on Promoting Quality Assurance in Public Works (below, the "Quality Assurance Act")" was submitted to the 162nd ordinary session of the Diet in 2005 as legislation by House members and came into effect on April 1 of the same year. Thereafter, the "Act on Promoting Quality Assurance in Public Works" (below, the "Revised Product Assurance Act"), which further amended the Quality Assurance Act, was promulgated and enforced in June 2014. In the Quality Assurance Act, it is stated that "the quality of public works must be ensured by contracts with comprehensively superior prices and quality considering various factors other than price while considering economic efficiency". Following the enactment of this law, it was decided to request technical proposals from competitors and shift to a "quality-and-cost-based selection method" in which the winning bidder is determined by comprehensively considering both price and quality, whereas the winning bidder was decided by only price competition in past bidding on public works.

Furthermore, while technical evaluation scores have conventionally been determined by adding the technical proposal additional points (10 to 50 points) to the standard points (100 points), the 2006 comprehensive evaluation brought instead a system where the points added to the standard points (100 points) are "construction standards evaluation points (out of 30 points) + technical proposal additional points (10 to 70 points)". In this method, if the bid price exceeds the standard minimum price for investigation, a perfect score (30 points) will be given unless there are special circumstances in which it is recognized that construction standards are not met. Then, if the bid price is less than the standard minimum for investigation, the points will be added only if the construction standards can be met. Because the comprehensive evaluation method for confirming construction standards excludes bid prices below the standard minimum for investigation in the quality-and-cost-based selection method by not awarding construction standards evaluation points in most cases, it was very effective as a dumping prevention measure [1].

At present, there is a strong tendency for bid prices to be concentrated slightly above the standard minimum for investigation. Dake et al. point out bidder tendencies, such as "getting into a price guessing game" or "eventually becoming mainly a price game". Moreover, they note that "the purpose of public procurement is to procure better things at lower prices. Considering this purpose, what should be required of bidders at the time of bidding is the ability to complete a better product at a lower price and the ability to accurately calculate the price corresponding to the enforcement content. The foremost requirement should not be accurately predicting the winning price of the order. They also note that this significantly impairs the motivation of engineers on the bidder side and is also unfavorable from the perspective of social costs [3].

1.2 Research objectives

Many harmful effects have been attributed to the tendency for bid prices to be concentrated slightly above the standard minimum for investigation. It is extremely important to train and secure the construction work leaders and ensure appropriate construction standards in order to eliminate the harmful effects of the system and promote competition based on the bidder's qualities, such as technical capabilities, efforts, and strategies.

The MLIT has declared that “an ordering party should properly examine technical abilities of competitors, strive to seek technical proposals related to ensuring and improving construction quality, and as a result, should assume the bidder who is the most superior in a price and technical suggestion generally a successful bidder” as the principle of the quality-and-cost based selection method. Comprehensive consultation with the Ministry of Finance has adopted the division formula shown in Equation (1) as the method for the comprehensive evaluation of construction work. The evaluation score by the division method is based on the concept of VFM (Value for money) and is an index showing the quality per price, so it is a method applied when further improving the construction quality by technical proposal. The denominator of Equation (1) is the value specified by the bidder, and the evaluation items for the technical evaluation of the numerator are the following three items: 1) company ability, 2) engineer ability, and 3) technical proposal (construction plan) [4].

1) Company ability: Evaluation of the ability of the company to carry out the construction appropriately and reliably based on the specifications presented by the ordering party. The evaluation depends on the accomplishment of the firm, construction results, awards, etc. of the company.

2) Engineer ability: Evaluation of the ability of the engineer who is directly involved in the construction to carry out the construction. The evaluation depends on the construction results, awards, the hearing result (supervision ability, degree of understanding) of the engineer, etc. of the engineer.

3) Technical proposal (construction plan): Evaluation of the ability of the company to improve the standard specifications presented by the ordering party and perform the quality improvement of the construction by its own technical proposal. The evaluation depends on the realization method about the securing of general cost, performance, function of the construction object and environmental maintenance, traffic [4].

Figure 1 shows the tendency for bid prices to be concentrated slightly above the standard minimum for investigation and the problems that occur when this tendency is eliminated in the quality-and-cost-based selection method. The bid price on the horizontal axis and the technical evaluation score on the vertical axis is the denominator and numerator of Equation 1, respectively. The evaluation value is the tangent of the angle θ formed by the straight line connecting the points (i.e., the bid price and technical evaluation score) and the origin and the horizontal axis. Therefore, the larger the angle, the higher the evaluation value, and the value of point A2 is $\tan\theta_{A2}$. Furthermore, the figure shows an example of bidding with two parties: A and B, where A shows the transition of three points of A1, A2, and A3, while B shows the transition of two points of B1 and B2. Points A1 and B1 indicate a bid price slightly higher than the standard minimum for investigation. Points A2 and B2 are points where the bid price has increased, although the technical evaluation scores have not changed from A1 and B1, respectively. Because there is no big difference between the bids prices of A and B when the bid prices are slightly higher than the standard minimum for investigation, A1 with a high technical evaluation score has a higher evaluation value than B1 ($\tan\theta_{A1} > \tan\theta_{B1}$). As a result, A wins the bid. However, in the state transition to A2 and B2, the evaluation value of B2 is higher than that of A2 ($\tan\theta_{B2} > \tan\theta_{A2}$), the winning bidder is reversed, and B with a low technical evaluation score wins the bid. This result is contrary to "the quality of public works must be ensured by contracts with comprehensively superior prices and quality considering various factors other than price while considering economic efficiency" that is required by the quality assurance method shown in the subsection 1.1. More specifically, to satisfy these requirements, the distribution of bid prices should have a wide range such that the tendency to concentrate slightly above the standard minimum for investigation can be eased; in addition, for bidders with a high technical evaluation score to bid successfully, it is necessary to create a situation where technical evaluation scores have a wide distribution and high scores can be obtained.

$$\text{Evaluation score} = \text{Technical evaluation score} / \text{Bid price} \tag{1}$$

The purpose of this study is to obtain quantitative knowledge about measures to alleviate the tendency for bid prices to be concentrated slightly above the standard minimum for investigation, as well as to identify the issues that arise when the tendency is alleviated. To this end, we built a simulation model that expresses that tendency and then changed the "distribution of technical evaluation score" and the "distribution of the difference between the bid price and the survey reference price". Finally, we made a case-to-case comparison using fluctuated variables, identified the variables that the ordering party should implement, and organized the target values.

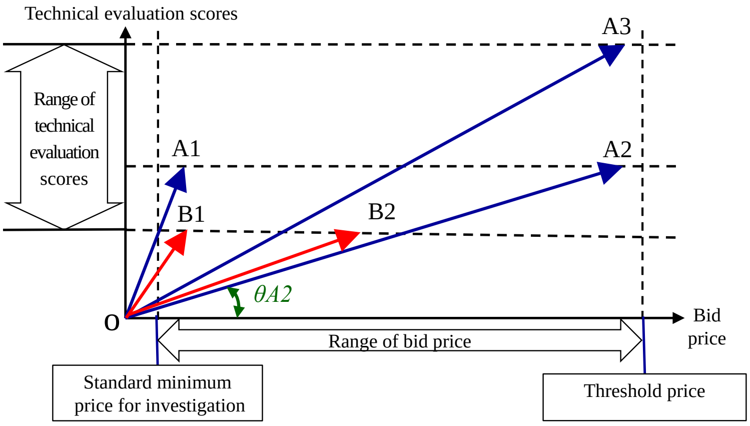

Figure 1. Relationship between bid prices, technical evaluation scores, and evaluation values

2. Previous study

There is no research on setting a lower limit on the bid price for public works outside Japan. In the present study, we first summarize the two viewpoints that are the subjects of this research in Japan. The first looks at factors such as historical changes in institutions, while the other statistically analyzes actual data. We then show an example of research on a method for determining the winning bid overseas, which is used as a reference in the present research.

In an analysis from the perspective of historical changes in institutions, Dake et al. (2013) explained the contents described in subsection 1.1 with bidding records for the World Trade Organization (WTO) quality-and-cost-based selection method for construction projects ordered by the MLIT from 2007 to 2010. Additionally, tendencies of bid prices to be concentrated slightly above the standard minimum for investigation also apply to methods other than the WTO standard comprehensive evaluation method, as shown in section three [3].

Kinoshita et al. (2008) gave an overview of the changes in the bidding system from the Edo period onward. They discussed the historical background, such as the principle of the open bidding system based on the accounting law of 1897, the establishment of a designated competitive bidding system to nominate excellent contractors in Royal Decree No. 280 of 1883, a new establishment in 1902, and the move to a general competitive bidding system with a comprehensive evaluation method in 2005. Furthermore, they analyzed the success of anti-dumping measures by conducting a special priority survey on extremely low bids in 2006 and confirmed the construction standards in the comprehensive evaluation method. Also, they showed that because winning bidders were those who bid lowest in the old system, while winning bidders were those with the highest score in the quality-and-cost-based selection method, low bids are not omitted using the low bid survey system alone. To solve this problem, they concluded that it is necessary to examine the construction standards of the contractor before finalizing a contract, and to establish a mechanism that allows the next-ranked bidder to make a winning bid without necessarily offering the lowest price [5].

Statistical analysis of actual data was performed by Matsumura et al. (2011) to examine changes in the bidding and contract system when the general competition method and quality-and-cost-based selection method were expanded, the construction standard confirmation type was introduced, and after 2005 when the standard minimum price for investigation was raised. They extracted the factors that changed the winning bid rate since 2006 and performed multiple regression analysis with the winning bid rate as the explained variable. As a result, they clarified that in general civil engineering works, the factors that influenced the fluctuation in the winning bid rate were the setting of a standard minimum price for investigation and the number of bidders. Bidders were shown to have changed their behavior and to bid higher when the minimum price for investigation was higher because the estimated multiple regression coefficients were positive. The estimated regression coefficient for the number of bidders was negative. This confirmed that an increase in the number of bidders increased competitiveness and reduced the winning bid rate. Also shown was that because the number of bidders is known after bidding, it is appropriate to interpret that the higher the number of bidders, the more competitive the pricing. [6].

Kaneko et al. (2012) analyzed the variability and changes in technical evaluation scores and bid prices among competitors in bidding by the quality-and-cost-based selection method using data for the 6 years from 2005 to 2010. They confirmed that the variation among bidders decreased with time, and that differences in technical evaluation score were less likely to occur. On the other hand, while the bid price did not change as much as the technical evaluation score over time, the variation tended to decrease, and it was found that price differences were unlikely to occur. The analysis results indicated that price competition might increase further in the future because the technical evaluation in the quality-and-cost-based selection method does not function effectively from the viewpoint of selection among bidders [7].

The following are previous studies on methods for determining the winning bid in overseas public procurement.

Ioannou et al. (1993) compared the lowest price automatic bid method and the average price bid method for determining winning bidders and claimed the superiority of the average price bid method. They claimed that the lowest price automatic bidding method was based on pure price competition, and its advantage was that it encourages bidders to make ongoing technical and administrative cost-cutting efforts, and for the competitive bidding process to work, the ordering party would benefit as a result. Also, they claimed that one of the disadvantages was that if a company that bid an impossibly low price was the winning bidder, regardless of whether the bid was incorrect or intentional, there would be many disputes, process delays, quality compromises, cost increases, and damages to both parties. Based on these assumptions, Ioannou et al. proposed a winning bidder determination method that considered the average bid price. Furthermore, they performed a Monte Carlo simulation on the assumption that the probability distribution of "bid price / required cost" was a normal distribution and this variable was set independently among bidders. They then summarized the results of the lowest price automatic bid method and the average price bid method. They argued that the average price bidding method might have a variation effect by lowering the winning bid slightly below the average value and moreover, fraudulent bidding could occur, such as setting up a dummy bidding company, making a high bid, and raising the average price. As mentioned above, the advantages and disadvantages of the average price bidding method were listed, before concluding that the method was necessary to eliminate low-priced orders for the survival of construction companies and to improve the relationship between orders. This study by Ioannou et al. is a case of previous research that includes suggestions for considering variations centered on the average bid price as criteria for determining the winning bid when the lower limit constraint by the standard minimum price for investigation is abolished [8].

Tadelis (2012) discussed what the public sector procurement method should be in comparison with private sector transactions. He showed that public procurement is based on open bidding due to institutional restrictions, while private sector transactions are less institutionally bound and more often negotiated to price. He then states that open bidding in particular prevents fraudulent activities such as bribery, which is easy for the procurement department to fall into in private transactions. Furthermore, they classified the goods and services to be procured into simple projects with requirements that could be determined in advance, and complex projects that required a long-term perspective in consideration of the final situation. The simple projects were competitive bidding with a fixed winning bid because the complete procurement specifications could be fixed, while the complex projects were procurement specification based on incomplete design, so it is desirable to negotiate with a reliable company on the assumption that the winning bid could change. He explained that a reason for defining simple projects versus complex projects was that when a contract change occurs, the winning bidder has two motivations; one is to suppress the cost increase due to the change and the other is to avoid unnecessary and costly renegotiation. When the winning bid is fixed, there is a strong incentive to suppress the cost increase when the specifications change, and if this is unavoidable, it becomes a dispute. However, because the negotiation method is premised on price changes, the dispute does not occur [9]. In addition, Tadelis points out the relationship between the procurement method and the occurrence of fraudulent bidding. For public institutions, there is a law that makes open competitive bidding, as strongly requested by Federal Acquisition Regulation (FAR), where the open bidding method ensures transparency and fairness; however, the negotiation method is prone to fraudulent acts such as bribery, and so in public procurement, an open bidding method may prevent fraudulent activities [9].

Trigo (2013) developed a multi-agent model for pricing on the premise that the roles and positions of consumers and suppliers would change in the future electric power market. Trigo defined a "prosumer", who played the role of both producer and consumer as an agent in this model, on the premise that electricity supply in the future would be a competitive with multiple parties, rather than be composed of a small number of powerful companies, as was the case previously. Moreover, the agents are not just producer and consumer capabilities but rather human beings who aim to maximize profits; then, an operator input data to the computer display in an interactive format. The contents that the operator input to the agent model is the amount of power provided and the price at the time of bidding. Based on the bid information input to multiple agents, this system sorted the agents in ascending order of bid price and the amount of power was totaled until the request from the ordering party was satisfied, finally resulting in a winning bidder. This method was an example in which multiple agents worked together to derive a market solution corresponding to one order where it was possible to implement strategic decision making. In addition, similar to the threshold price system for public procurement in Japan, an upper limit was set for the bid price in this market, and bids exceeding this limit were excluded. The simulation result shows that the bid result of the electric power market that enables the setting of electric energy according to the requirement at a low price. This is an example of simulating the bidder's behavior and the process leading up to the result for bidding in one market and expressing the future image with a multi-agent simulation model. The reference case was when the bidder's strategy was set by a human [10].

3. Status confirmation using actual data

This section organizes specific basic information for analysis in a simulation of the qualitative trends and phenomena shown in this paper so far, and confirms the findings with actual data targeted in this study. The data used are the estimation standard for construction under the direct control of MLIT regarding the system [11].

In addition, we referred to the Kanto Regional Development Bureau of the MLIT [12] for data such as the number of individual bids and contracts, and bidders. We set the number of effective digits in the analysis to 6 based on the general and administrative expense ratio of the integration standard [11], and the value of other factors such as the bid and winning bid in millions of yen according to published figures. Analysis results other than these were set as appropriate according to the purpose of the study.

3.1 Relationship between the bid and standard minimum for investigation

Table 1 shows the basic statistics for FY2008, FY2013, and FY2018 for the value obtained by dividing the bid price by the standard minimum price for investigation (i.e., ratio to the investigation standard), and Figure 2 shows the distribution of the standard minimum ratio for FY2008 and FY2018. The number of data items was 2,854, 2,860, and 1,940, in FY2008, FY2013, and FY2018, respectively. In FY2013, the average value was 1.04, which is the same as that in FY2018, so during this period, the bids were already concentrated slightly above the standard minimum for investigation. Comparing FY2008 and FY2018, the mean value changed from 1.09 to 1.04, and the standard deviation changed from 0.076 to 0.055. The difference between the bid and the standard minimum for investigation was close to 10% in FY2008, but was 4% in FY2018, indicating that the bid was extremely close to the standard minimum for investigation. Furthermore, from the shape of the graph in Figure 2, we can see that the bids in recent years have tended to concentrate slightly above the standard minimum for investigation.

Next, we compare this tendency with the transitions of other variables and analyze its cause. Figure 3 and Figure 4 show the price ratio of the bid to the minimum from FY2008 to FY2018, and the changes in the total number of bidders and the number of construction projects, which represent the size of the bid market. The price ratio of the bid to the minimum is the average value for each bidding item in each year, and the total number of bidders and the number of construction works are the actual total number in each year. After the Great East Japan Earthquake struck in March 2011, the Japanese government designated FY2011-FY2015 as an "intensive reconstruction period" and FY2016-FY2020 as a "reconstruction and creation period", and has been proceeding with efforts including securing financial resources according to the Cabinet decision document in FY2019 [13]. During the 10 years from 2008 to 2018, the number of construction works increased in 2011, when the "intensive reconstruction period" started, although the market size has since shrunk. As shown in Table 2, both the number of construction projects and the total number of bidders in FY2018 decreased to about half that in FY2008. Furthermore, the table shows the price ratio of the bid to the minimum was 1.16 in FY2008 and 1.05 in FY2018. This quantitatively shows that the bid price in Figure 2 approaches the survey standard price. From the abovementioned changes in the ratio to the survey standard and the total number of bidders and the number of construction projects over the past 10 years, the bid price was found to have approached levels that were slightly higher than the standard minimum for investigation as the market size shrank. This and the fact that the number of construction projects and the total number of bidders are positive correlation coefficients, as shown in Table 3, show that the cause of the phenomenon that the bid prices are concentrated slightly above the standard minimum for investigation is as follows. A bidder might try to lower the bid price to increase the winning bid probability due to the shrinking market size; however, the bid price must exceed the standard minimum for investigation because it must follow the construction standard confirmation in the quality-and-cost-based selection method. The reasons why the ratio of the survey criteria in Table 1 and Table 2 are different are discussed below. Table 1 shows the average value of the values for each bid item corresponding to Figure 2, and Table 2 shows the bid price and the standard minimum price for investigation as values obtained by calculating the annual total value and dividing them because they must have the same annual value as the number of construction projects and the total number of bidders.

Table1. Basic statistics of the standard minimum price ratio

Name of statistic	Fiscal year		
	2008	**2013**	**2018**
Average value	1.091	1.041	1.043
Standard deviation	0.076	0.041	0.055
Maximum value	1.383	1.181	1.536
Minimum value	0.689	0.814	0.890
Differences between maximum and minimum	0.694	0.367	0.646

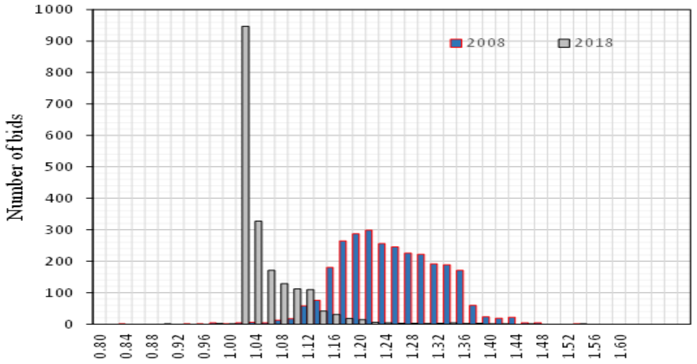

Figure 2. Distribution of standard minimum price ratio

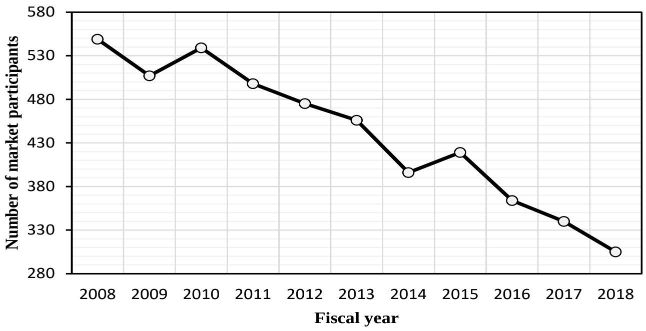

Figure 3. Transition of the minimum price ratio

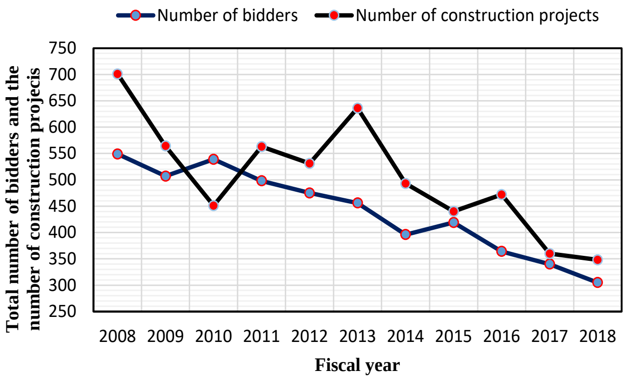

Figure 4. Changes in the total number of bidders and the number of construction projects

Table 2. The 2018/2008 ratio of the number of construction projects, total number of bidders, and minimum price ratio

Variable name	2008	2018	2018/2008
Number of construction works	701	348	0.4964
Total number of bidders	549	305	0.5556
Minimum price ratio	1.1635	1.0535	0.9055

Table 3. Rank correlation coefficient of the minimum price ratio with number of construction projects, and total number of bidders

Variable name	Rank correlation coefficient
Number of construction works	0.7841
Total number of bidders	0.9659

3.2 Relationship between bid price and technical evaluation score

We confirmed the correlation between the technical evaluation score and the bid price in Equation 1 that defines the evaluation value. If a relationship is found, the result should be reflected in the model, and if no relationship is found, each value is calculated independently.

The technical evaluation scores in the general civil engineering work data released by the Kanto Regional Development Bureau of the MLIT were listed as the total value of the basic points (100 points) and the additional points [11], so we used additional points as the data to be analyzed. The number of data points used in the analysis FY2018 was 1,776, excluding the data for which no additional points were added because the bid price exceeded the planned price in all 1,940 cases. Spearman's rank correlation calculated between the additional points and the bid price was 0.33 in 2018, and the P value (two-sided test) was 3.41974×10^{-48}, which means that the null hypothesis of no correlation at the 5% significance level was rejected. Therefore, we found it necessary to relate the bid price and the technical evaluation score in the simulation model.

3.3 Relationship between bid price and related factors

We conducted a multiple regression analysis to confirm the presence or absence of influence, a positive or negative relationship between the bid price and the threshold price, the number of bidders, the additional point, and the revision of standard minimum price for investigation, which were all elements recognized in previous research and used in the simulation model for general civil engineering work in 2008-2018. The results of this analysis are shown in Table 4. The reason for using each element as an explanatory variable is as follows.

The threshold price was used as an explanatory variable to realize the impact of the construction scale of the participating bid projects as a premise of bidding behavior. Although the number of bidders is unknown to bidders at the time of bidding, the number cannot be an explanatory variable for setting bid prices. Because it was concluded in the study by Matsumura et al. [6] that the bid price was explained significantly, we decided that it was necessary to introduce their conclusion into the present analysis. The additional points are necessary as explanatory variables in the model to reflect the relationship between the bid prices and technical evaluation scores obtained in subsection 3.1. The intercept is the value when all explanatory variables are zero.

As shown in Table 4, the coefficient of the number of bidders shows that competition becomes fiercer as the number of bidders increases and shows a negative relationship with bid price. The coefficient of the additional points is positive because an increase in the points means an increase in the denominator of Equation 1, and the bid price can be increased in order to maintain the evaluation value. The coefficients of all dummy variables that indicate the increase in the bid price survey reference price are positive, showing an increase in bid prices and reflecting the purpose of preventing dumping orders.

We verified that bid prices tended to be concentrated slightly above the standard minimum for investigation and that there was a trend toward an increase in successful bidders with high technical evaluation scores in the actual data described in section 2. To evaluate the strictest situation as an index showing the technical level of the winning bid result, we used the numerical value related to the case where the winning bidder's technical evaluation score was ranked first. Table 5 shows the percentage of winning bids by the bidder with the highest technical evaluation score among the construction projects with two or more bidders in FY2008 and FY2018. This ratio increased from about 66% in FY2008 to about 81% in FY2017. This indicates that the determinants of the winning bidder are shifting to the technical evaluation score in the numerator. That is, as shown in Figure 2, the bid prices were distributed and concentrated around the standard minimum for investigation from FY2008 to FY2018, and there is no difference in the denominator of Equation 1.

Table 4. Multiple regression analysis results for bid price

Variable name	Unit		
Bid price	Million yen		
Threshold price	Million yen		
Number of bids	Bidder		
Additional point	Point		
Multiple correlation R			
Correction R2	0.998385165		
Coefficient of determination R2	0.996772937		
Adjusted R-square R2	0.996772031		
Standard error	53.45490333		
Number of samples	24936		
	Coefficient	**t**	**P**
Intercept	-12.96388455	-8.263158058	1.48848E-16
Threshold price	0.900915139	2688.476834	0
Number of bidders	-0.452559915	-8.62239925	6.93977E-18
Additional point	0.19723208	7.473882325	8.04233E-14
DM1(H23_24)	5.654302273	5.775925033	7.74408E-09
DM2(H25_27)	11.9979765	13.24548669	6.53795E-40
DM3(H28_28)	11.82693355	8.929226056	4.57905E-19
DM4(H29_30)	14.11600944	9.812060611	1.09824E-22

Table 5. Percentage of winning bidders with the highest technical evaluation score

Variable name	2008	2018
Number of construction projects	586	283
Number of successful bids	317	231
First bid rate (%)	54.10	81.63

4. Development of simulation model

In the simulation model, bid prices, technical evaluation scores, and evaluation values were calculated for each bidder and each bid item, then the bidder with the highest evaluation value was taken as the winning bidder. The simulation model consists of three phases, as shown in Figure 5. Artisoc textbook 2.6 [14] was used for model development and operation. The contents of Figure 5 are described below. The variables shown in the figure are designated as < > to indicate that they are different from other general variables.

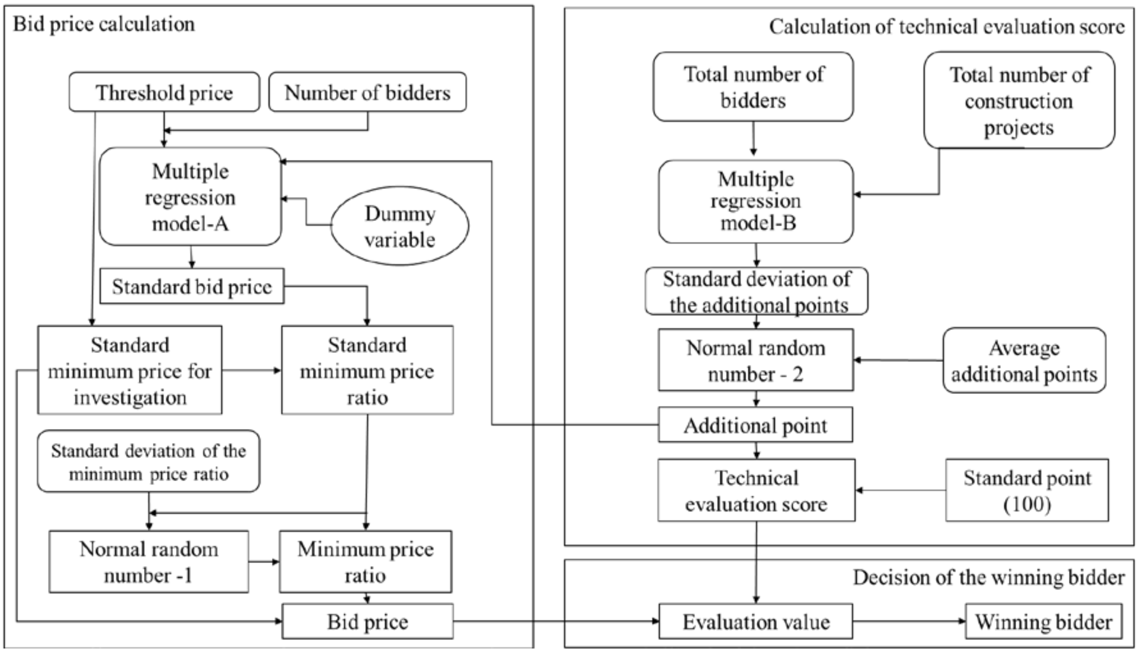

Figure 5. Schematic flow of simulation model

4.1 Calculation of bid price

Bid prices were calculated based on the <standard bid price> set at the model price. The <standard bid price> is the bidding price that is calculated by the multiple regression model shown in Table 4, and is calculated by inputting the two exogenous variables (i.e., <threshold price> and <number of bidders>), with <additional points> and <dummy variable> described in the next subsection. The obtained <standard bid price> is divided by the < standard minimum price for investigation > to obtain the <standard minimum price ratio> (i.e., standard <bid price / standard minimum price for investigations >). <Standard to minimum price ratio> indicates the standard value of the degree of deviation between <standard minimum price for investigation> and <bid price>. In order to generate a different <minimum price ratio> (i.e., bid price / standard minimum price for investigation) for each bidder in the simulation, we calculate a normal random number with the <standard to minimum price ratio> as the mean value and the exogenously given <standard deviation of the minimum price ratio> as the standard deviation. The <standard minimum price for investigation> is calculated by multiplying the exogenously given <threshold price> by the ratio of the <standard minimum price for investigation> to the <planned price> shown in the next subsection (i.e., the standard minimum price for investigation / threshold price).

From Table 1 and Figure 2, the tendency for bid prices to be concentrated slightly above the standard minimum for investigation is alleviated by going back to the past, so we set the target situation in the simulation to FY2008.

As shown in Figure 2 and Table 6, the <standard to minimum price ratio> (<bid price / standard minimum price for investigation >) does not have a normal distribution in FY2018, but the skewness tends to approach 0 and the kurtosis tends to approach 2 as it goes back to FY2008. Therefore, we assumed that the <standard to minimum price ratio> follows a normal distribution.

We set dummy variables in order to reflect the effect of raising the survey standard price, with the dummy variable set to 1 in the periods of FY2011-FY2012, FY2013-FY2015, FY2016, and FY2017-FY2018 at the time of raising the explanatory variable, and to 0 in other periods.

4.2 Calculation of technical evaluation scores

The technical evaluation score is calculated by adding the additional points and the standard points (100 points). Because the standard score is fixed at 100 points in the "construction standard confirmation in the quality-and-cost-based selection method" described in subsection 1.1, we calculated instead the additional points in the simulation model rather than technical evaluation scores. As shown in Table 6 and Figure 6, the values in FY2008, FY2013, and FY2018 were stable at almost 50 points; therefore, we set the average value at 50 points. Because the mean value was fixed, the standard deviation of the additional points (i.e., <standard deviation of the additional points> in Figure 5) directly affected the additional points. Because we considered that the size of the market and the increase in bidding opportunities due to the number of participants in the market depended on the width of the distribution of technical evaluation scores, in our model this standard deviation was calculated using the multiple regression model in Table 7 based on the macroscopic trends in Table 3 and Figure 4.

As shown in Table 6 and Figure 6, the kurtosis of the additional points is smaller than 3, which indicates a lighter tail than the normal distribution, and the skewness is smaller than ± 1.00, which so indicates a tendency toward symmetry. Thus, we judged the additional points to follow a normal distribution. Therefore, the additional points were obtained from the normal random number in Figure 5 based on the mean value and standard deviation obtained above.

Table 6. Statistics of standard minimum price ratios and additional points

Fiscal year	Statistic name	Standard minimum price ratio	Additional point
2008	Average value	1.16	50.41
	Standard deviation	0.1025	19.1970
	Kurtosis	1.91	-0.08
	Skewness	0.92	-0.70
2013	Average value	1.08	50.52
	Standard deviation	0.0714	13.6244
	Kurtosis	48.68	1.51
	Skewness	4.64	-0.12
2018	Average value	1.05	51.16
	Standard deviation	0.0530	9.3604
	Kurtosis	22.26	1.78
	Skewness	3.44	0.63

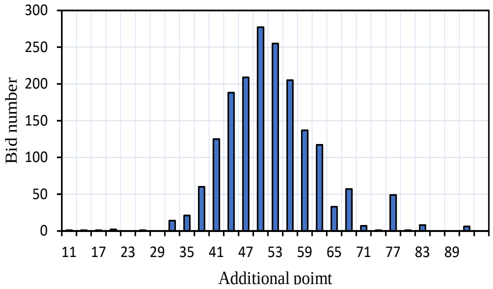

Figure 6. Distribution of additional points in FY2018

Table 7. Multiple regression analysis results of the standard deviation of additional points

Variable name	**Unit**		
Number of bidders	Bidder		
Number of construction works	Work		
Multiple correlation R			
Correction R2	0.896663976		
Coefficient of determination R2	0.804006287		
Adjusted R-square R2	0.755007858		
Standard error	1.784178855		
Number of samples	11		
	Coefficient	**t**	**P**
Intercept	-5.406745028	-1.729367844	0.121998919
Number of bidders	0.030824086	2.977982745	0.01765468
Number of construction works	0.008030045	1.022866846	0.336302975

5. Simulation

5.1 Simulation case settings

The purpose of this study was to examine whether the tendency for bid prices to concentrate slightly above the standard minimum for investigation has been alleviated and to check whether the technical evaluation scores of winning bidders were lower than before this tendency was alleviated. The purpose was also to identify measures to prevent the deterioration of technical evaluation scores as much as possible. In order to achieve these aims, we used case setting from two perspectives in our simulation. In the first perspective, we examined factors that influence the technical evaluation scores of the winning bidder in addition to the above trends. The target elements were the threshold price and the number of bidders, which were the exogenous variables shown in Table 4 and Figure 5. The threshold price indicates the scale of the construction to be bid, and the number of bidders indicates the competitive state. The second perspective is the case where the bid price tends to be concentrated slightly above the standard minimum for investigation. In order to create such a case, it is necessary to confirm the abovementioned tendency due to the difference in the distribution of the bid price and the technical evaluation scores in Figure 1, and we set the target variables as the minimum price ratio and the additional points. Then, from Table 1 and Figure 2, we set the "desired target year" as FY2008, which was the year when the bid prices were not concentrated slightly above the standard minimum for investigation. The case setting method for these variables is described below.

5.1.1 Case setting according to project scale

We assumed that bidding behavior would differ depending on the scale of the bidding construction project and set up a simulation case accordingly. We set an index showing the scale of the project at the threshold price.

According to the planned price [12] of general civil engineering work announced by the Kanto Regional Development Bureau of the MLIT in FY2008 and FY2018, large-scale construction is scattered, although the number is small. We determined that the scale of the projects analyzed in this study, with the exception of these few large-scale projects, occurred with a cumulative composition ratio of about 95% in both years, as shown in Table 8.

Grouping by project scale was based on the ratio of general and administrative expenses, etc. to the threshold price. General and administrative expenses, etc. is the expense required for continuous operation of a company involved in construction work [11] according to the estimation standard. This ratio is considered to be an element that reflects the bidding behavior of bidders. According to the estimation standard [11] for FY2018, the ratio of general and administrative expenses, etc. to the threshold price for companies whose construction cost exceeds 5 million yen and is 3 billion yen or less, is as shown in Equation 2; Here, G_p is the general and administrative expense ratio, and x is the construction cost (unit is yen).

$$Gp = (-5.48972log10x + 59.4977) / 100 \tag{2}$$

In addition, the definition of the construction contract amount is given by Equation 3, where the threshold price given in yen is under the current integration standard [11]. Given the construction cost x in Equation 2, the general and administrative cost equality ratio G_p can be obtained from Equation 2. The pair “planned price” and “general and administrative expenses, etc.” can be obtained from Equation 2 and 3.

$$r = x(1 + Gp) \tag{3}$$

Table 8. Composition ratio by project size

	Threshold price (Million yen unit)	**Composition ratio (%)**	**Cumulative composition ratio (%)**
Fiscal year 2008	0	0.00	0.00
	100	23.49	23.49
	200	36.32	59.81
	300	30.60	90.41
	400	1.39	91.80
	500	1.55	93.35
	600	**0.77**	**94.12**
Fiscal year 2018	0	0.00	0.00
	100	15.45	15.45
	160	21.57	37.02
	340	53.07	90.09
	480	2.33	92.42
	600	2.33	94.75
	720	**0.58**	**95.33**

Figure 7 displays the “planned price” and general and administrative expenses, etc.” in FY2018 graphically. In FY2008, the tendency is the same because the functional form is the same, except for the coefficient. As shown in Equation 2, the general and administrative expense ratio is a logarithmic function with a base of 1/10 of the construction cost and is monotonically decreasing. Moreover, as shown in the figure, with regard to change in price per unit, when the threshold price is small, the decrease in the general and administrative expense ratio is large; and as the threshold price increases, the decrease in the general and administrative expense ratio decreases. That is, the behavior determined by the bidder based on the rate of change differs depending on the level of the threshold price. This consideration indicates the need for grouping to show the difference in bidding behavior depending on the scale of the threshold price. These groupings were based on the rate of change in the elastic value of the rate of change in the “general and administrative expenses, etc.” when the threshold price changed by 1%. Table 9 shows the calculation results and grouping results from Equation 2 and 3 in the range of Table 8 based on the abovementioned specifications. The prices that were analyzed in FY2013 and FY2018 were 25.70 to 596.81 (million yen) and 28.24 to 721.61 (million yen), respectively, as displayed in the rightmost column. Furthermore, in FY2018, the threshold prices for small-scale, medium-scale, and large-scale ranged between approximately 28 and 138 (million yen), approximately 139 and 217 (million yen), and approximately 217 and 722 (million yen). Then, as shown in Table 10, the set results were grouped within the range of 0.0002 or more, 0.0024 to 0.0018, and 0.0017 or less for the difference in elastic value. Because the distribution in each group was asymmetric, we set the representative value at the median.

5.1.2 Case setting based on the number of bidders

Because the number of bidders is not known to the bidders at the time of bidding, that information is not considered to affect bidding behavior. However, in consideration of multiple regression analysis and previous studies, we decided that it is necessary to understand the number of bidders as a policy variable because it affects the bid price. We therefore use our simulation to examine the influence of the difference in the number of bidders on the technical evaluation scores of the winning bidders. Table 11 and Figure 8 show the distribution of the number of bidders by project for all cases in FY2018. As shown here, the number of projects tends to decrease as the number of bidders increases, where projects with 2 bidders account for about 16% of the total, and those with 3 to 7 bidders accounts for about 42%, so that 2 to 7 bidders account for about half the total. About half of the bids with 8 or more bidders are distributed infrequently. From these, the number of bidders in the simulation was set to 3 groups of 2 bidders, 3 to 7 bidders, and 8 or more bidders, with the number of representative bidders in each group set to 2, 5, and 10 bidders, respectively.

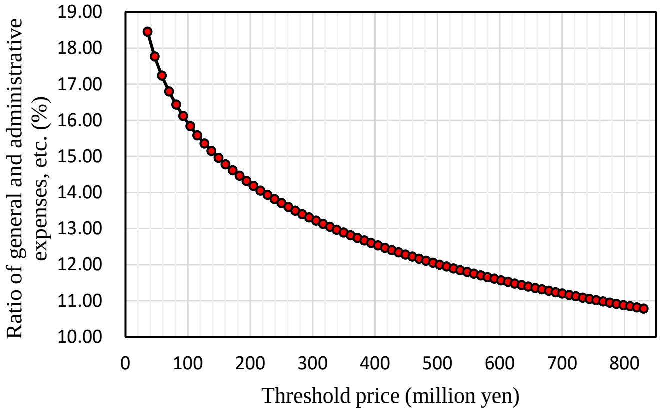

Figure 7. Changes in elastic value between threshold price and ratio of general and administrative expenses, etc. in FY2018

Table 9. Basis for project scale grouping

Construction scale	Construction cost (x)	Threshold price (r)	Ratio of general and administrative expenses, etc. (%) (Gp)	Elasticity value	Difference in elasticity	Actual threshold price
Small scale	20.00	22.56	12.824	0.072	—	**25.70**
	••••	••••	••••	••••	••••	**••••**
	70.00	78.00	11.422	0.093	0.0023	**89.22**
Medium size	80.00	89.02	11.273	0.095	0.0020	**90.65**
	••••	••••	••••	••••	••••	**••••**
	200.00	220.50	10.248	0.108	0.0007	**220.85**
Large scale	210.00	231.41	10.193	0.108	0.0007	**221.60**
	••••	••••	••••	••••	••••	**••••**
	550.00	600.14	9.116	0.123	0.0003	**596.81**
Small scale	20.00	23.88	19.417	0.114	—	**28.24**
	••••	••••	••••	••••	••••	**••••**
	120.00	138.17	15.145	0.155	0.0002	**137.64**
Medium size	130.00	149.44	14.954	0.157	0.0024	**139.28**
	••••	••••	••••	••••	••••	**••••**
	190.00	216.69	14.050	0.169	0.0018	**216.6**
Large scale	200.00	227.85	13.927	0.171	0.0017	**217.15**
	••••	••••	••••	••••	••••	**••••**
	650.00	722.26	11.117	0.218	0.0007	**721.61**

(Amount unit: million yen)

Table 10. Grouping results of project scale (million yen)

Threshold price by scale (median)		
Small scale	**Medium size**	**Large scale**
97.22	174.45	258.28

5.1.3 Case setting based on the distribution of the minimum price ratio

The minimum price ratio (i.e., bid price / standard minimum for investigation) is a value indicating the degree of concentration of the bid price slightly above the standard minimum for investigation. As mentioned above, the phenomenon of bid prices being slightly higher than the standard minimum for investigation is the current situation in FY2018, and the desired target in FY2008. We calculated the standard deviation of the minimum price ratio (bid price / standard minimum for investigation) from the past slightly above the standard minimum for investigation would. All the data shown in Figure 2 include rare bids that appear to be outliers. We extracted the data, as shown in Table 12, in order to obtain simulation results that enable us to compare the tendency toward concentration in FY2018 and the tendency toward concentration relaxation in FY2008. Because the average value of the standard minimum price for investigation (i.e., the standard minimum price for investigation / threshold price) within the scale of the project to be analyzed in FY2018 is 0.8964 (standard deviation: 0.006633), the value used in the simulation was the planned price multiplied by 0.8964. As shown in section 4, the average value of the minimum price ratio was the standard minimum price ratio dividing the standard bid price obtained by the standard minimum price for investigation.

Table 11. Number of construction projects by number of bidders in FY2018

Number of bidders	Number of construction projects	Composition ratio
1	65	18.68
2	**57**	**16.38**
3	38	10.92
4	33	9.48
5	**33**	**9.48**
6	21	6.03
7	21	6.03
8	15	4.31
9	6	1.72
10	**7**	**2.01**
11	9	2.59

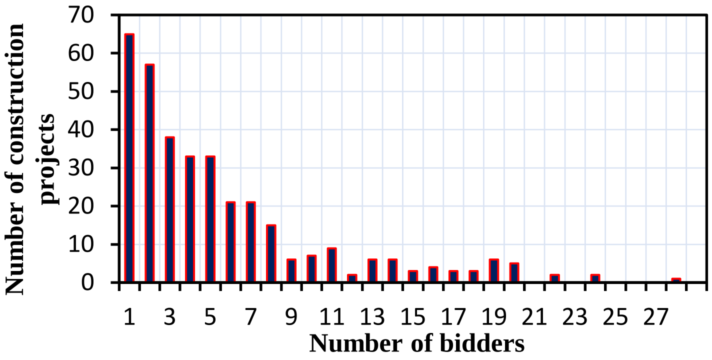

Figure 8. Distribution of the number of bidders in FY2018

Table 12. Ratio of minimum price ratio used in the simulation model

Fiscal year	Minimum price ratio	Total number of cases	Extraction summary			
			Number of applications	Extraction rate	Minimum value	Maximum value
2008	0.0591	702	526	0.7493	1.0604	1.2795
2018	0.0124	348	204	0.5862	1.0202	1.0898

5.1.4 Case setting based on the distribution of additional points

The average value of the added points was fixed at 50 points according to the past transition shown in Table 6. To calculate the additional points, we used the average values of the total number of bidders and the number of construction projects in the three cases of pre-earthquake, intensive reconstruction period, and reconstruction and creation period, as shown in Figure 3 and Table 13.

5.1.5 Simulation premise and setting case

In a general civil engineering publication by the Kanto Regional Development Bureau of the Ministry of Construction [12] used in this study, the maximum number of bids in FY2018 was 44 by 2 bidders. Based on this, we set the number of bids, which we use as the number of trials, at 100 times this value. For the dummy variables in the simulation, the coefficient of "dummy (FY 2017, FY2018)" was adopted in accordance with the policy for the standard minimum for investigation set in FY2018. As shown in subsection 5.1.1, the cases due to the difference in the attributes of the project are large, medium, or small depending on the project scale, and 2, 5, or 10 depending on the number of bidders.

We set the case for the survey reference ratio and the additional points, which are variables set using normal random numbers, based on the difference in standard deviation. That is, the names of the cases in which both variables were set to FY2008 and FY2018 were [H20] and [H30], such that the case where the standard deviation of the additional points in FY2008 and the standard deviation of the survey standard ratio in FY2018 was [Additional points H20], while the case where the standard deviation of the additional points in FY2018 and the standard deviation of the survey standard ratio in FY2008 was [Survey standard H20]. Table 14 shows the case names for the survey reference ratio and the distribution of additional points.

Table 13. Explanatory variables for the standard deviation of the points of additional changes in the total number of bidders and the number of construction projects

Period		**Total number of bidders**	**Number of construction projects**
Pre-earthquake	2008	549	701
	2009	507	564
	2010	539	451
	Average value	**528**	**572**
Intensive reconstruction period	2011	498	563
	2012	475	531
	2013	456	636
	2014	396	493
	2015	419	440
	Average value	**449**	**533**
Reconstruction and creation period	2016	364	472
	2017	340	360
	2018	305	348
	Average value	**336**	**393**

Table 14. Simulation case names due to differences in distribution

Variable name	**Fiscal year**	**Standard deviation of the minimum price ratio**	
		2008	**2018**
Standard deviation of the addition points	2008	H20	[Addition point H20]
	2018	[Survey standard H20]	H30

5.2 Simulation results

In this subsection, we compare the results obtained by the simulation with the actual values and examine the differences. We then examine the estimation results based on the project size and the number of bidders. Based on these results, we analyze the possibility of alleviating the tendency of bid prices to concentrate slightly above the standard minimum for investigation and securing the level of technical evaluation scores of the winning bidders. The values of the simulation results for each variable shown in this subsection are the average values of 100 trials, as explained in the previous subsection.

5.2.1 Comparison with actual results

Table 15 shows the simulation results and actual values of case [H30] in Table 14. The bid rate was estimated to be about 2% lower, and the winning bid rate was within 1%. The reason why the bid rate was estimated to be low is that the purpose of this study is to examine bids in the low-price range, and because the bid price was based on the deviation from the survey standard price, it tended to be lower than the actual value. As a result, the minimum price ratio was estimated to be low as well. In addition, the minimum price ratio was around 1.01, compared with the actual 1.04, with the simulation showing a stronger tendency of bid prices to be concentrated slightly above the standard minimum for investigation than the actual value. Because the estimated bid price was too low, there was a strong reproduction of the tendency of bid prices to be concentrated slightly above the standard minimum for investigation, and the winning bid rate almost equaled the actual value, we determined that the simulation results could be analyzed in this study.

5.2.2 Project scale

As shown in Table 15, the difference in the scale of the projects did not affect the bid rate, winning bid rate, winning bid probability of the bidder with the highest technical evaluation score, or the minimum price ratio. However, as shown in Table 16, the standard deviation of bid prices varied depending on the scale of the project.

The cause of this variation is as follows. The bid price for this model is calculated by multiplying the minimum price ratio by the standard minimum price for investigation. The minimum price ratio was set with a normal random number based on the "standard deviation of that ratio" given exogenously and its "mean value". This "mean value" was the ratio of the standard minimum price ratio in Figure 5, and this value was affected by the threshold price in the multiple regression equation. Therefore, the difference in the threshold price affects the ratio between the bid price and the standard minimum price for investigation.

Table 15. Comparison of estimated and actual values in FY2018

Variable name	Estimated value				Actual value for FY2018
	Number of bidders	Construction scale			
		Small	Medium	Large	
Bid rate	2	0.9073	0.9073	0.9073	0.9338
	5	0.9069	0.9069	0.9069	
	10	0.9061	0.9061	0.9061	
Winning bid rate	2	0.9162	0.9116	0.9097	0.9087
	5	0.9027	0.9027	0.9027	
	10	0.9010	0.9010	0.9010	
Probability of winning bid having the highest technical evaluation score	2	91	91	91	82
	5	83	83	83	
	10	85	85	85	
Minimum price ratio	2	1.0121	1.0121	1.0121	1.0427
	5	1.0117	1.0117	1.0117	
	10	1.0108	1.0108	1.0108	

Table 16. Standard deviation of bid in FY2018

Number of bidders	Construction scale		
	Small	Medium	Large
2 bidders	1.0813	1.9403	2.8727
5 bidders	1.0666	1.9139	2.8336
10 bidders	1.0709	1.9215	2.8449

5.2.3 Number of bidders

The number of bidders had a large influence on the selection of the winning bidder. As shown in Table 17, the difference in probability that the highest bidder with the technical evaluation score would be the winner was 19% at the maximum between 2 and 5, and there was a tendency for the technical evaluation scores of the winning bidders in two-party bidding cases to be high. However, in the case of 10 bidders, bids did not differ from those in the case of 5 bidders. As shown in Table 18, the probability that the bidder with the highest technical evaluation score would be the winner was higher in the case of 2 bidders than in the case of a larger number of bidders, and the probability that the bidder with the highest technical evaluation score would be the winner was lower in the case of 5 or more bidders that in the case of 2 bidders, and the same probability tended to be dispersed after the second-ranked bidder.

5.2.4 Comparison between cases

From the above analysis, we found that the influence of the scale of the project was small and the influence of the number of bidders was large. Therefore, as shown in Table 19, the project scale was taken as the average value of the estimated values for each case, and the number of bidders was analyzed using the estimated values for each number of bidders.

Table 17. Difference in winning bid probability for bidders with the highest technical evaluation score

Case name	Changes in the number of bidders	Difference in bid probability
H30	2-5	8
	5-10	-2
[Survey standard H20]	2-5	19
	5-10	0
[Additional points H20]	2-5	8
	5-10	-2

Table 18. Winning bid probability by number of bidders, case, and technical evaluation score ranking

Number of bidders	**Case name**	**Rank**					
		First rank	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**
2	H20	79	21				
	H30	91	9	-	-	-	-
	[Additional points H20]	96	4	-	-	-	-
	[Survey standard H20]	70	30	-	-	-	-
5	H20	65	23	9	3	0	
	H30	83	16	0	1	0	-
	[Additional points H20]	88	11	1	0	0	-
	[Survey standard H20]	51	25	14	10	0	-
10	H20	65	19	9	6	1	0
	H30	85	14	0	1	0	0
	[Additional points H20]	90	9	1	0	0	0
	[Survey standard H20]	51	16	12	7	11	3

The bid rate was estimated to be higher in [Survey standard H20] than in [H30], and the results showed that the distribution of bid prices was wide. The winning bid rate was estimated to be lower than that of [H30], which is similar to the examination result in subsection 1.2, where the spread of the distribution of bid prices lowers the winning bid rate. In addition, as the number of bidders increase in both [Survey standard H20] and [H30], competition becomes fiercer and both the bid rate and the winning bid rate tend to decrease.

The probability of the winning bidder having the highest technical evaluation score is high, where [Additional points H20] exceeds [H30] by 5%. The technical evaluation scores of the winning bidders were increased by expanding the width of the distribution of the additional points by the values shown in Table 13 by the formula in Table 7. However, this probability was extremely low in [Survey standard H20], and among the cases of 5 and 10 bidders, almost half of the winning bidders were not ranked first. This result indicates that about half of the winning bidders would have technical evaluation scores not ranked first if there had been easing of the tendency of bid prices to be concentrated slightly above the standard minimum for investigation, and when the price was expanded toward the threshold price. In addition, [H20], which was considered to be a desirable era, was 65% for both 5 and 10 bidders. [H30] was 83% and 85% for both 5 and 10 bidders, respectively, and [H20] was estimated to be about 20% lower than [H30]. These findings show that the winning bid probability of the bidder with the highest technical evaluation score decreases by about 20% in projects with more than 2 bidders. This result shows that the technical evaluation score of the winning bidder had decreased due to the relaxation of the tendency for bid prices to be concentrated slightly above the standard minimum for investigation examined in subsection 1.2.

As shown in Table 18, the winning bid probability for [H20] and [H30] including the technical evaluation scores up to the second-ranked bidder is the same as that of the first-ranked bidder. This is because in projects with 5 or 10 bidders, [H20] was 88% and 84% which is almost the same as 83% and 84% in [H30], respectively. That is, if the bid price was less, the tendency for bid prices to be concentrated slightly above the standard minimum for investigation was alleviated, because the percentage of winning bidders with the highest technical points would decrease by about 20%, and if the second-ranked bidders were included, the same level as the current first-ranked bidders would be secured. From this, we found that if the abovementioned tendency to concentrate slightly above the standard minimum for investigation was alleviated, it was possible to maintain the same winning bid probability for bidders with the highest technical evaluation score by making it possible for the bidders with the second-highest technical evaluation score to make a winning bid.

5.2.5 Additional points

From the results of the simulation results examined by [Additional points H20], we confirmed that expanding the range of additional points increases the winning bid probability for the bidder with the highest technical evaluation score. Because the additional points are elements that can be operated by the ordering party, we examined specific points.

Table 20 shows the maximum and minimum values for each standard deviation of the additional points by simulation. It was possible to realize all cases by setting the minimum and maximum values to around 6 to 9 points and 100 points, respectively. In the FY2018 actual data [12] used in this study, the maximum additional points was 90 points and the minimum additional points was 11 points. Therefore, in the simulation result, the probability of the winning bidder having the highest technical evaluation score could be increased by setting the maximum additional score to 100 points.

Table 19. Estimated results by case (average of large, medium, and small scales)

Variable name	**Case name**	**Number of bidders**	**Estimated value**	**Evaluation of results**
Bid rate	H30	2	0.9073	Low
		5	0.9069	
		10	0.9061	
	[Survey standard H20]	**2**	**0.9148**	**High**
		5	**0.9129**	
		10	**0.9090**	
	[Addition point H20]	2	0.9073	Low
		5	0.9069	
		10	0.9061	
Successful bid rate	H30	2	0.9097	Low
		5	0.9027	
		10	0.9010	
	[Survey standard H20]	**2**	**0.9040**	**High**
		5	**0.8631**	
		10	**0.8482**	
	[Addition point H20]	2	0.9134	High
		5	0.9036	
		10	0.9022	
Probability of winning bid having the highest technical evaluation score (%)	**H20**	**2**	**79**	**-**
		5	**65**	
		10	**65**	
	H30	2	91	Medium
		5	83	
		10	85	
	[Survey standard H20]	2	70	Low
		5	51	
		10	51	
	[Addition point H20]	**2**	**96**	**High**
		5	**88**	
		10	**90**	
Minimum price ratio (bid price / standard minimum price for investigation)	H30	2	1.0121	Low
		5	1.0117	
		10	1.0108	
	[Survey standard H20]	**2**	**1.0205**	**High**
		5	**1.0184**	
		10	**1.0140**	
	[Addition point H20]	2	1.0121	Low
		5	1.0117	
		10	1.0108	

6. Conclusion

In recent years, the dumping prevention function has been successful due to multiple factors, such as the standard minimum price for investigation system and the quality-and-cost-based selection method for confirming construction standards. The number of very low bids for construction under the direct control of the MLIT has decreased in Japan [1]. However, there is a tendency for bid prices to be concentrated slightly above the standardminimum for investigation, and bidders have therefore fallen into a "price guessing game". It has been pointed out that this tendency impairs the motivation of bidders and is not a favorable situation from the perspective of social costs [3]. In this study, we first confirmed the situation in which lower bid prices occur due to the wider distribution of bid prices, and bidders with lower technical evaluation scores are successful in bidding when that tendency was eased for the division type of quality-and-cost-based selection method. Then we analyzed the simulation results to obtain quantitative basic knowledge about this situation. The data used are the published values of the bidding results from the Kanto Regional Development Bureau of the MLIT. In the simulation, the distribution derived from the actual data for the past 10 years was set as the target case in FY2008, centering on FY2018.

Table 20. Maximum and minimum additional points for each case(Variable name: Additional point)

Case name	Number of bidders	Lowest point	Highest point
H20	2	9.05	99.88
	5	9.05	99.88
	10	6.73	99.88
H30	2	28.50	76.19
	5	28.50	76.19
	10	27.28	76.19
[Survey standard H20]	2	28.50	76.19
	5	28.50	76.19
	10	27.28	76.19
[Additional points H20]	2	9.05	99.88
	5	9.05	99.88
	10	6.73	99.88

The simulation result was that the percentage of winning bidders with the highest technical evaluation score decreased by 10% in cases of 2 bidders, and by about 20% in cases of 5 or 10 bidders. Also, by including the second-ranked bidder, the same ratio as that of the current first rank was secured when the bid price was less concentrated slightly above the standard minimum for investigation. In addition, we found that by expanding the upper limit of the additional points from the current 90 points to 100 points, the winning bid probability of the bidder with the highest technical evaluation score improved by about 5% from the current situation. Furthermore, when the distribution of bid prices was expanded to that of FY2008, about half of the winning bidders had technical evaluation scores that were not ranked first.

The parameters of the constructed model were limited to the time and region of the data published by the Kanto Regional Development Bureau from FY2008 to FY2018 [12]. Although the data used in this study were confirmed to be consistent with the application results in previous studies, the following should be conducted in the future: a wide range of studies on exogenous variables that should be set as policy variables, confirmation of the accuracy and generality of the parameters, and strengthening of the explanatory power of the simulation.

In this study, we analyzed the characteristics of bid results on the premise of the quality-and-cost based selection method applied in bidding contracts for public works projects in Japan. In the quality-and-cost based selection method, a bidder with the highest evaluation value obtained by bid prices set by bidders and technical evaluation scores set by the ordering party is decided as a successful bidder. Therefore, this study is applicable to any country that adopts or intends to adopt the winning bidder determination method that considers the evaluation values such as technical evaluation and construction period in addition to the bid price. In addition, when constructing a model, actual data are indispensable because it is necessary to analyze the distribution by statistical analysis in order to set parameters, initial values, etc.

7. References

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