査読付論文

Impact of the Characteristics of Contractors on the Construction Quality of Public Works

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ABSTRACT

This study aimed to clarify whether the characteristics of contractors and the winning bid rate impact the quality of construction projects. The winning bid rate is the ratio of the winning bid amount to the target price, which is the estimated amount determined by the client based on the substance of the work and the required technology. This study used data on the pre-qualification system and construction quality evaluation for public works in Japan. We conducted an empirical analysis using panel regression to examine whether contractor characteristics and winning bid rates affect construction quality. The empirical analysis showed that the quality of construction projects tended to be high for contractors with high profitability, financial soundness and technical expertise. Moreover, the quality tended to be high for contractors with high winning bid rates. The originality of this research lies in its use of quantitative data from the actual pre-qualification system and construction quality evaluation and statistical methods to demonstrate the relationship between the winning bid rate, characteristics of contractors and quality of public works projects.

Keywords

quality, public works, pre-qualification, empirical analysis, construction

1. Introduction

The infrastructure built through public works is an important form of social capital that supports people's lives and economic and social activities over the long term. Therefore, contractors undertaking public works must maintain high-quality, providing advanced technical proposals and smooth construction. In addition, as the main funding sources for public works are taxes and public bonds, promoting competition among contractors and ensuring that public works are bid and carried out at reasonable prices is desirable. For these reasons, the public works tendering and contracting system is constantly required to maintain quality and competitiveness (Ministry of Land, Infrastructure, Transport and Tourism, 2022a).

When a public tender is issued in Japan, the contract is awarded to the bidder who has submitted the lowest bid among the submitted bids below the target price. The target price is the client's maximum construction budget that accurately reflects the actual construction situation, such as the latest labour and material costs. The target price can also be regarded as an estimate made by the client, determined according to the substance of the construction project and the technology required for it.

If the contractor is chosen based on price alone, there is a high risk of dumping orders. Dumping orders are contracts where the amount of the contract does not usually allow for the proper construction of public works. Dumping orders will likely lead to cutting corners on construction work, passing the buck to subcontractors, worsening the wages and other working conditions of those engaged in public works, inadequate safety measures, etc. In turn, dumping orders can cause a decline in the number of young people entering the construction industry, making it difficult to train and secure the people who will carry out construction work. This could hinder the healthy development of the construction industry.

Therefore, Japan has a lowest-limit price system and a low-bidding price investigation system to prevent dumping orders (Public Works Bidding System Research Group, 2010).

Under the lowest-limit price system, a certain percentage of the target price (for example, two-thirds of the target price, eight-tenths of the target price, etc.) is set as the lowest-limit price for competitive contracts. Bids that do not reach the lowest-limit price will be invalid, even if they are the lowest price within the target price limit. In other words, it is a system in which the lowest bidder among those who bid above the lowest-limit price within the range of the target price limit is determined to be the successful bidder.

In the low-bidding price investigation system, the target price and standard price are set in advance; when the bidding price falls below the standard price, an investigation is conducted to determine whether the contract can be adequately fulfilled. Government agencies and local governments are permitted to introduce this system.

From the perspective of increasing the effectiveness of eliminating dumping orders, the Ministry of Land, Infrastructure, Transport and Tourism is promoting the introduction of a low-bidding price investigation system for ordering parties. It is possible to evaluate the system in two stages: price and possibility of fulfilment of contract. In addition, Ministry of Land, Infrastructure, Transport and Tourism (2021a) states that if ensuring the effectiveness of the low-bidding price investigation system is difficult or if there is a risk that an appropriate low-bidding price investigation cannot be performed, the use of the lowest-limit price system should be considered necessary.

According to Ministry of Land, Infrastructure, Transport and Tourism (2022b), all government institutions have introduced a low-bidding price investigation system. Furthermore, prefectures and government-designated cities have almost all introduced a low-bidding price investigation system and a lowest-limit price system. Conversely, many cities, wards, towns and villages have only introduced the lowest price limit system. This disparity occurs because the lowest-limit price system (which can automatically exclude bidders whose prices are below the standard price) is easier to introduce than the low-bidding price investigation system (which requires considerable effort to prepare the screening criteria and system).

In recent years, in Japan, several high-profile cases of poor expertise by contractors have received substantial media attention, which has drawn public attention to the issue of ensuring the quality of public works projects. In response, Ministry of Land, Infrastructure, Transport and Tourism (2021b) announced that it would strengthen cooperation with prefectures by taking strict action against poor and unqualified contractors and providing new cooperation, such as by monitoring the ongoing business conditions of contractors after problems are discovered.

Oshima et al. (2018) investigated shoddy construction in public works in Japan. According to Kyushu Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (2016), shoddy construction refers to a condition in which the completed work has defects, and it is defined by the requirement that the cause of such defects lies with the contractor, regardless of whether the cause was intentional or unintentional. Based on statistical data, Oshima et al. (2018) highlighted that shoddy construction continues to occur for causes such as insufficient on-site checks, lack of technical skills and experience (e.g. inappropriate construction methods) and deliberate dishonesty. As such, construction defects remain an issue in ensuring the quality of public works.

This study empirically analyses the characteristics of contractors who carry out high-quality public works. Specifically, this research examines the relationship between the construction quality evaluation of contractors by the client and the characteristics of the contractors. This approach allows us to clarify the actual status of contractors who execute high-quality construction projects. In addition, this study analyses the relationship between the construction quality evaluation of contractors by the client and the winning bid rate to clarify the impact of the winning bid amount on construction quality. The winning bid rate indicates the intensity of competition in the bidding.

This study provides suggestions for the future of the public works bidding and contracting system. Clarifying the actual situation of contractors who have performed high-quality construction work can contribute to future selection criteria for contractors. Moreover, analysing the impact of winning bid rates on construction quality can provide suggestions for ensuring quality and maintaining competitiveness in the public works bidding and contracting system.

This study is organised as follows: the literature review section presents the literature review, while the research question section outlines this study's purpose and research questions. The data section explains the dataset and statistical analysis methods, while the results section presents the empirical analysis results. The discussion section discusses the analysis results, and the conclusion section provides the conclusion.

2. Literature review

2.1 Performance evaluation of the contractors

Several existing studies have examined the overall performance of construction (including time, cost and quality) and the factors involved (Tam and Harris, 1996; Cheung et al., 2008; Aje et al., 2009; Xia et al., 2009; Alzahrani and Emsley, 2013). However, few studies analyse the factors that affect construction quality in particular. For example, Tam and Harris (1996) surveyed Hong Kong contractors and empirically analysed their construction performance. Tam and Harris (1996) interviewed the client and used a comprehensive cost, time and quality evaluation of construction performance. Cheung et al. (2008) used data from the Hong Kong Housing Department to investigate the success factors of comprehensive performance evaluation, including quality. Their analysis revealed that past performance scores had the most significant impact on future performance scores. In contrast, Tam and Harris (1996) and Cheung et al. (2008) analysed the factors that affect the comprehensive evaluation but did not analyse the factors that affect quality alone.

Various studies have analysed the factors that particularly affect construction quality (Hatush and Skitmore, 1997; Jha and Iyer, 2006; Doloi, 2009; Enshassi et al., 2009). Hatush and Skitmore (1997) conducted a survey in the United Kingdom regarding the relationship between the selection criteria for contractors and the success factors (time, cost and quality) of construction projects, finding that past failures, financial situations, financial soundness and engineers impacted quality. Jha and Iyer (2006) surveyed experts in the Indian construction industry. They identified factors that contribute to success, such as the competence of the project manager, support from top management, monitoring of and feedback from project participants, interaction between project participants and the competence of the client. Factors leading to poor quality were conflict between project participants, a hostile socio-economic environment, harsh climatic conditions, ignorance and lack of knowledge on the part of the project manager, errors in project conception, uniqueness of the project, and aggressive competition during the bidding process. Furthermore, Doloi (2009) surveyed contractors in Melbourne to investigate the factors that affect their performance. This analysis revealed that the work method statement, technical experience and track record of safety initiatives significantly affect construction quality. Enshassi et al. (2009) conducted a questionnaire survey of construction-related professionals in the Gaza Strip, finding that the availability of highly experienced and qualified personnel most affects construction performance.

The above studies were mainly based on questionnaire surveys, and few studies have analysed the results of the governmental construction quality evaluation system. Furthermore, most of the studies analysed the quality of each construction project, so there is little empirical analysis of which contractors carried out high-quality construction work.

2.2 Methods of selecting contractors

This section summarises research on methods for selecting contractors. Holt et al. (1994), Wong (2004) and Topcu (2004) indicated that selecting a contractor is generally a matter of identifying a contractor who can meet the client’s time, cost and quality expectations and satisfactorily complete the client’s project.

Cost-based contractor selection (CBCS) is a method for construction owners and clients to select contractors based primarily on the competitiveness of the bid price. However, CBCS may cause some problems with project performance. For example, Holt et al. (1994) suggest that selecting contractors based on the lowest bid price may affect project performance in terms of cost, quality and time. Therefore, contractors should be selected based on their best performance rather than on the lowest bid price. Furthermore, Olaniran (2015) surveyed contractors in Brunei, showing that the CBCS results in delays in construction projects and non-compliance with construction standards; these effects are mainly attributable to the decline in the profit margin for contractors.

For this reason, contractors are now selected through pre-qualification and tender evaluation, which consider various factors in addition to cost (Holt et al., 1994; Holt, 1998; Wong, 2004; Topcu, 2004; Lam et al., 2005; Ogunsemi and Aje, 2006; Mbachu, 2008; Jafari, 2013).

Holt (1998) found that it is desirable to select contractors using the following two-stage procedure—

Stage 1: pre-qualification; Stage 2: evaluation of bidders. In the first stage, all contractors wishing to bid should be screened regarding organisational standards. The first-stage criteria include past performance, experience and financial soundness. In the second stage, the suitability of specific contractors for the proposed project should be assessed. The project-specific criteria for the second stage include the office's location in relation to the project, experience in the geographical area and experience with the proposed construction method. Furthermore, Ogunsemi and Aje (2006) investigated pre-qualification screening and bid evaluation in the Nigerian construction industry. They found that past performance, contractor experience, bid price, plant equipment and quality of expertise were the most critical factors in selecting contractors. Finally, Mbachu (2008) investigated the criteria used by South African contractors when selecting subcontractors. Their analysis revealed that the quality of the work of the subcontractors was the most crucial factor, both at the pre-qualification stage and at the preconstruction stage.

As noted above, it has been pointed out that the CBCS method for contractor selection may cause problems in project performance. Therefore, alternative selection methods that take into account factors beyond price have been developed. In particular, the past construction quality of contractors, as demonstrated by their previous performance, is considered an important factor in the criteria for selecting contractors in future projects.

3. Construction quality

The question of how to evaluate construction quality has long been discussed in the literature (Yasamis et al., 2002; Best and Langston, 2006; Hoonakker et al., 2010).

The construction quality evaluation system is used in construction projects directly managed by the Japanese Ministry of Land, Infrastructure, Transport and Tourism. Construction quality evaluations are commonly used in public works projects in Japan. In this system, the client evaluates the quality of the work and the construction situation comprehensively at each technical inspection and upon completion of the work. Ministry of Land, Infrastructure, Transport and Tourism (2013) has explained that construction performance evaluation ensures the proper and efficient execution of contracted construction work and contributes to improving construction technical standards; furthermore, it contributes to the proper selection, guidance and training of contractors. In principle, construction quality evaluation is for contracts worth more than 5 million JPY. The types of construction covered include river, coastal, erosion control, dam, road and park/green space construction projects ordered by the Regional Development Bureau. The assessment is performed by a three-person team consisting of assessors called technical inspectors, general supervisors and senior supervisors. The assessment items are given a maximum score of 100 points and classified into seven categories: construction system, construction status, shape and quality of work, characteristics of the work, originality and ingenuity, social responsibility and compliance with laws and regulations. Detailed checklists have been prepared for each of these categories.

The construction quality evaluation system was created to ensure appropriate and efficient execution of works and to improve technical standards (Ministry of Land, Infrastructure, Transport and Tourism, 2013). In the official implementation guidelines, the sub-item quality alone receives 17.4 of the 100 available points—the largest single weighting—while the allied items dimensional accuracy and appearance add a further 23.4 points, underscoring that conformity of workmanship and materials lies at the heart of the assessment (Ministry of Land, Infrastructure, Transport and Tourism, 2013). The guideline for preparing construction quality evaluation system manuals for public buildings opens by declaring that the construction quality evaluation must have a single overarching aim, namely to ensure the quality of public construction works, and it explicitly grounds this requirement in the 2005 Act on Promoting Quality Assurance of Public Works (Ministry of Land, Infrastructure, Transport and Tourism, 2006). A ministerial briefing paper further explains that the evaluation aims to discourage quality deterioration and to incentivise contractors to improve their construction techniques so as to secure quality (Ministry of Land, Infrastructure, Transport and Tourism, 2005). The construction quality evaluation system scores are determined from the findings of on-site technical inspections together with a review of documented quality-control records; as a result, the score constitutes an objective assessment of the completed work (Ministry of Land, Infrastructure, Transport and Tourism, 2010). Nakamura et al. (2008) stated that the construction quality evaluation results are already used in bid pre-qualification precisely to safeguard quality. Aizawa (2006) analysed 12,716 civil engineering contracts completed in fiscal year 2003. The study found that projects awarded at unusually low tender prices had an average construction quality evaluation score of 69.1 points. In contrast, projects awarded at standard prices averaged 74.2 points. The 5-point difference between these two groups can be partly attributed to differences in the quality sub-item. This suggests that variations in workmanship quality contribute to the construction quality evaluation score differences.

The construction quality evaluation score can be considered a valid indicator of construction quality for three reasons. First, the evaluation scheme has a well-designed institutional framework. Second, it has a clear statutory purpose. Third, empirical evidence continues to support its effectiveness. Based on these factors, this study uses the construction quality evaluation score as the measure of construction quality.

4. Research question

This section explains the research question. Public spending on public works is sluggish, yet demand is rising for advanced disaster-prevention projects and for renewing aging infrastructure. In the market, construction quality is likely to depend on which contractor is chosen. This study advances the hypothesis that the quality of a contractor's financial and technical resources determines project performance. Contractors that continually invest in recruiting and training skilled workers show resilience, upholding specifications even when sudden design changes occur or material prices soar. Contractors with weak financial bases, unable to fund workforce development or equipment upgrades, are forced to shift excessive costs to subcontractors or shorten schedules, conditions that can let construction defects remain hidden. As explained in detail in Section 5, this study uses ordinary profit margin, debt turnover period, ratio of engineers, and prime-contract completed work value as proxy variables for contractor characteristics, and ACQE as the proxy for construction quality, to test whether disparities in contractors' resources influence construction quality.

In recent years, public works projects have been awarded under fierce price competition: local governments face tight budgets while demand for recovery and disaster-prevention projects is concentrated, so contract values stagnate even as the variety of projects grows. This environment produces a winner's curse that drives the successful bidder's profit margin to very low levels, encouraging hidden cost cutting such as downgrading material specifications or shortening inspection steps. Orders lack the engineers and funds to monitor construction continuously, so information asymmetry persists, and quality problems often appear only after completion. An aging, chronically short labour force and soaring material prices further narrow the funds available for quality assurance in low-price contracts. As a result, excessive cost cutting ripples from prime contractors to subcontractors and sub-subcontractors, diluting accountability and allowing minor construction defects and durability weaknesses to remain hidden. The above presents our hypothesis that excessive price competition leads to a decline in construction quality. As will be defined in detail in Section 5, this study treats a winning bid rate as a proxy for the intensity of price competition and ACQE as a proxy for construction quality and investigates whether price competition affects construction quality.

Based on the reasons discussed above and the findings of previous studies, this study uses data from the Japanese construction quality evaluation system to research the impact of the characteristics of each contractor and the winning bid rate on quality. Existing studies have examined the quality of construction work using questionnaires; however, few studies have analysed the relationship between the characteristics of each contractor and construction quality using actual data from the government's construction quality evaluation system. Therefore, this study was conducted to fill the apparent research gap. Specifically, this study focused on contractors' profitability, financial soundness, technical capabilities and winning bid rates, analysing how these factors affect construction quality evaluation.

Hatush and Skitmore (1997) found that the better the financial situation, the higher is the construction quality evaluation. The current study follows this approach to set the following research question.

RQ1 : Does higher profitability for the contractors lead to higher construction quality evaluation?

Hatush and Skitmore (1997) found that the higher the financial soundness, the higher is the construction quality evaluation. Accordingly, we set the following research question.

RQ2 : Does better financial soundness of contractors lead to higher construction quality evaluation?

Hatush and Skitmore (1997), Doloi (2009) and Enshassi et al. (2009) found that the availability of highly skilled technical personnel positively impacted the construction quality evaluation. In line with this finding, this study sets the following research question.

RQ3 : Does a higher number of engineers employed by a contractor lead to higher construction quality evaluation?

Jha and Iyer (2006) found that the more intense the competition at the time of bidding, the lower is the construction quality evaluation. Therefore, this study sets the following research question.

RQ4 : Does the construction quality evaluation tend to be high when there is less competition in the bidding process?

5. Data and research methods

5.1 Data

The contractor characteristics used in this study are taken from the results notifications of the Business

Evaluation (Japanese: *Keiei Jikou Shinsa*) conducted annually by Japan's Ministry of Land, Infrastructure, Transport and Tourism for all licensed construction firms. The Business Evaluation is a Japanese pre-qualification screening system that contractors must undergo to undertake public works projects ordered by the national or local governments (Konno, 2014). Because the system is mandated by law, every construction company nationwide—listed and unlisted alike—must undergo this assessment, giving the dataset the crucial advantage of covering the entire public-works market under a single, consistent institutional framework. In addition, the information submitted includes corporate tax filings, engineers' qualification certificates, and other official documents, and the records are confirmed only after both desk and on-site inspections by the relevant authorities. This process ensures a high level of data authenticity and reliability, which is a significant strength for academic research. Moreover, because Business Evaluation scores feed directly into public-procurement practice, using their component indicators as explanatory variables in the analysis automatically secures policy relevance. For example, the estimates in this study provide concrete guidance on which elements of the Business Evaluation score contracting authorities should focus on to select contractors capable of delivering high-quality construction work.

This study empirically analysed how contractors' characteristics and winning bid rates affect future construction quality evaluations. The Kanto Regional Development Bureau only discloses the average construction quality evaluation score every two years; therefore, this study used the average construction quality evaluation score for the two years. Specifically, an empirical analysis was conducted using panel data on the relationship between the characteristics of contractors from 2011 to 2016, as well as the average construction quality evaluation for the two years from each point in time into the future. The Kanto Regional Development Bureau is responsible for the overall civil engineering and construction administration in the Kanto region, including Tokyo and parts of the Chubu region. This study used data from before the COVID-19 pandemic to exclude the effects of the disruption to social conditions caused by COVID-19. This study focuses on contractors who have obtained a Tokyo Governor's licence or a Minister of Land, Infrastructure, Transport and Tourism licence. These contractors must also have completed three or more construction projects ordered by the Kanto Regional Development Bureau within two years (from 2013 to 2018). The number of contractors used in the analysis is 199. The sample size for the panel data is 757.

5.2 Models used in the analysis

This study aims to clarify the relationship between the future construction quality evaluation of contractors and their characteristics. Therefore, this study uses panel regression analysis to empirically analyse the relationship between contractors' characteristics from 2011 to 2016 and future construction quality evaluations at each point. Model 1 includes financial variables and the ratio of engineers as explanatory variables. Model 2 adds the winning bid rate as an explanatory variable to Model 1. The relationship between the specific explained and independent variables is explained in the following subsections.

Table 1 presents the explanatory variables, their expected coefficient signs with respect to the explained variable—construction quality—and the basis for each expectation. The expected signs are derived from prior empirical studies and considerations discussed in Section 2.

Table 1: Expected coefficient signs and basis

Variable	Expected coefficient sign	Basis for expected sign
Ordinary profit margin	+	Contractors with strong financial status are judged most capable of meeting quality objectives (Hatush and Skitmore, 1997)
Debt turnover period	–	Better financial capacity is perceived to support quality performance (Hatush and Skitmore, 1997)
Average total prime-contract value	n.s.	Control variable for contractor scale
Ratio of engineers	+	Technical expertise significantly improves quality success (Doloi, 2009); highly qualified staff ranks top among quality factors Enshassi et al. (2009)
Winning bid rate	+	Aggressive price competition harms quality; conversely, higher winning bid rates leave margin for quality assurance (Jha and Iyer, 2006)

Note: n.s. = no specific expectation.

This study used a fixed-effects panel regression model for the empirical analysis. For details on the fixed-effects model, please refer to Cameron and Trivedi (2005) and Wooldridge (2010).

5.3 Explained variable

In Models 1 and 2, the explained variable—the average construction quality evaluation (ACQE)—is defined as the simple mean of the construction quality evaluations received by the contractor in the two years immediately following year t (i.e., years $t + 1$ and $t + 2$). For example, when the explanatory variable corresponds to 2011, the ACQE is calculated as the average of the contractor's construction quality evaluations for 2012 and 2013. By making the explanatory variable a variable from an earlier time than the explained variable, the reverse causal effect (i.e. the effect of construction quality evaluation on the explanatory variable) is removed. As noted in Section 3, the construction quality evaluation is an appropriate proxy variable for construction quality and therefore ACQE is likewise suitable.

5.4 Explanatory variables

The explanatory variables used in Model 1 represent the financial situation and the ratio of engineers among the characteristics of the contractors that are obtained from the Business Evaluation. The explanatory variables used in Model 1 include the ratio of ordinary income to sales, the debt turnover period, the average total contract work completed by the main contractor and the ratio of engineers.

Hatush and Skitmore (1997) found that the better the financial situation or financial soundness, the higher is the construction quality evaluation. However, they did not specify which concrete financial indicators should be used to measure these abstract concepts. Therefore, this study needs to select specific financial indicators.

This study adopts the ordinary profit margin as a financial situation measure. The ordinary profit margin is also an indicator of profitability. The ordinary profit margin is calculated by dividing the ordinary profit by the sales and multiplying by 100. The unit of the ordinary profit margin is %. In general, the ordinary profit margin indicates the profit margin of a company's overall business activities, including financial activities, and reflects the company's overall profitability. Therefore, the higher this value is, the more profitable the company is. The reasons for adopting the ordinary profit margin are as follows. First, the ordinary profit margin is a profitability measure weighted in the Y-score formula of Business Evaluation. This preserves institutional consistency. Second, the ordinary profit margin incorporates non-operating income and financing costs, thus reflecting the profit that truly remains after the long cash-conversion cycles characteristic of multi-year construction projects. Third, data analysis of the Business Evaluation database by Iwamatsu (2013) demonstrated that the ordinary-profit margin has three advantages: it shows relatively small dispersion, making it an accessible policy benchmark; it retains moderate inter-industry variation, allowing meaningful comparative analysis; and it is robust to outliers, which facilitates the statistical assessment of individual firms' financial condition. Fourth, major industry benchmark publications, including the Ministry of Finance's Financial Statements Statistics of Corporations, publish the ordinary profit margin as their headline profitability ratio, underscoring its sector-wide acceptance.

The debt turnover period was employed as a measure of financial soundness. The debt turnover period is an indicator of financial soundness, calculated by dividing the total debt by monthly sales. It indicates how many months' worth of sales are covered by debt. The unit of the debt turnover period is months. The larger the debt turnover period, the greater is the proportion of debt to sales and the higher is the probability of bankruptcy. The reasons for adopting the debt turnover period are as follows. The debt turnover period, which shows how quickly a contractor can repay the money it borrows, is one of the Y-score items in the Business Evaluation. Unlike the debt-to-equity ratio or the current ratio, which offer balance-sheet snapshots, the debt turnover period directly links debt to the contractor's operating scale. Public agencies rely on it because it tells them whether a contractor has enough financial strength to keep long projects running smoothly. Since the metric is defined in the same way for every contractor, orderers can compare contractors across Japan on a single, fair scale, keeping this analysis in line with real-world procurement practice. Recent empirical research confirms the indicator's practical value: Karas and Srbová (2019) analysed thirty-five financial ratios across over 4,000 Czech contractors and found that current liabilities-to-sales ratio—analogous to debt turnover period—was the sole debt variable in their final bankruptcy prediction model. Similarly, Špička (2013) demonstrated that failing contractors exhibited liability turnover ratios significantly lower than those of solvent contractors.

The average total prime contract work completion value is an indicator of the business size of a company, calculated in the unit of one billion JPY. This is the total value of work a company completes as a prime contractor for a client, regardless of the type of construction work, including public and private works. The applicant can choose whether to use the average of the past two years or the average of the past three years. The larger the average total prime contract work completion value, the larger the business size of the company is considered to be. The average total prime contract work completion value is an institutionally established indicator that captures both a contractor's scale and its performance capability at the same time. First, the metric is formally built into the Business Evaluation formula for the technical strength score (Z-score), so it directly represents the capacity to take primary responsibility for construction management—an ability public clients emphasise at the bidding stage. The focus on prime-contract work, rather than subcontract achievements, is intentional: experience overseeing the entire project—including safety management, schedule control, and quality assurance—is what truly governs performance risk in public works. Accordingly, using average total prime contract work completion value

Table 2: Descriptive statistics of variables

	N	Mean	SD	Min	Max
ACQE	757	77.22	1.87	60.00	82.00
Ordinary profit margin	757	2.94	2.07	-8.50	5.10
Debt turnover period	757	6.21	2.68	0.90	18.00
Average total prime contract work completion value	757	44.48	154.96	0.06	1229.44
Ratio of engineers	757	49.50	187.74	7.05	2682.11
Winning bid rate	757	91.01	2.98	82.93	99.72

Source: Author's own calculation, based on Stata/SE 18.0 software.

as an explanatory variable is appropriate: it aligns with public-procurement practice and provides an objective, comparable gauge of both a contractor's scale and its performance capability. This variable is treated as a control variable because it is not directly related to the RQ of this study.

The ratio of engineers is an indicator of the technical expertise of contractors and the availability of human resources. Specifically, it is calculated by dividing the total number of engineers by the average total prime contract work completion value; the result is then multiplied by one billion. The ratio of engineers is expressed as the number of engineers per one billion JPY of average total prime contract work completion value. The number of engineers refers to the total number of people with qualifications or education related to general civil engineering work (e.g. first-class management course participants, first-class engineers, core technicians, second-class engineers, other engineers, etc.). The higher the ratio of engineers, the greater is the number of specialist engineers per completed contract. Therefore, the ratio of engineers is used as an indicator to evaluate the technical expertise of a company's construction work and the state of its human resources. The ratio of engineers, introduced in this study, can be calculated entirely from data reported in Business Evaluation. This indicator quantifies whether a prime contractor assigns a level of engineering staff that matches the scale of its projects, capturing the human resource aspect of technical capacity in public works. It can be derived directly from Business Evaluation data, enabling public clients to compare contractors objectively. For these reasons, adopting it as an explanatory variable is both meaningful and well justified.

Model 2 used the winning bid rate as an explanatory variable, and the explanatory variables used in Model 1 were the contractor characteristics obtained from the Business Evaluation. Specifically, Model 2 used the ordinary profit margin, debt turnover period, average total prime contract work completion value, ratio of engineers and winning bid rate as explanatory variables.

The winning bid rate indicates the intensity of the price competition in bidding. The winning bid rate is calculated by dividing the winning bid price by the target price and multiplying it by 100. The unit of the winning bid rate is expressed as a percentage. The winning bid rate is the average for each company for that year. The higher the winning bid rate, the closer the winning bid price is to the target price. The client sets the target price by considering changes in socio-economic conditions and making an estimate that accurately reflects the market prices of labour, materials, etc. and the actual state of implementation. When many contractors compete, strong rivalry pushes the winning price far below the target price, lowering the

Table 3: Correlation matrix of variables

	Var 1	Var 2	Var 3	Var 4	Var 5	Var 6
Var 1	1.000					
Var 2	0.229***	1.000				
Var 3	−0.051	−0.214***	1.000			
Var 4	0.002	−0.012	0.229***	1.000		
Var 5	−0.052	0.031	−0.096***	−0.054	1.000	
Var 6	−0.026	0.071*	−0.075**	0.037	0.196***	1.000

Var 1 = ACQE, Var 2 = Ordinary profit margin, Var 3 = Debt turnover period
Var 4 = Average total prime contract work completion value, Var 5 = Ratio of engineers, Var 6 = Winning bid rate
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

winning-bid rate. Conversely, when competition is weak—because there are few participants or some are screened out beforehand—the winning-bid rate rises, approaching the target price. Thus, the winning-bid rate serves as a sound quantitative proxy for the intensity of price competition in public-works bidding.

Table 2 shows the descriptive statistics of the variables used in this analysis.

Table 3 presents the correlation matrix, calculated to assess potential multicollinearity among the explanatory variables. The correlation coefficients between explanatory variables range from -0.214 to 0.229, with the highest correlation being 0.229 between debt turnover period and average total prime contract work completion value. These correlation coefficients are well below the commonly used threshold of 0.7-0.8 for multicollinearity concerns. Based on this diagnostic test, multicollinearity does not pose a problem for the model specification.

6. Results

The results of the regression analysis are summarised in Table 4. The analysis was conducted at the 10% significance level. The results of Model 1 show that the ordinary profit margin and the ratio of engineers have a positive and significant impact on ACQE. Furthermore, the debt turnover period had a negative and significant impact on the ACQE. Furthermore, the average total prime contract work completion value had no significant impact on ACQE. In summary, companies with high profit margins, high financial soundness and high ratios of engineers tended to have high ACQE.

The results of Model 2 show that the ordinary profit margin, the ratio of engineers and the winning bid rate have a positive and significant impact on ACQE. Moreover, the debt turnover period negatively and significantly impacted ACQE. However, the average total prime contract work completion value did not significantly impact ACQE. In summary, companies with high profit margins, financial soundness, engineer ratios and winning bid rates tended to have high ACQE.

Model 1 has an Akaike information criterion (AIC) of 2261.768, and Model 2 has an AIC of 2257.245; therefore, Model 2 is adopted based on the AIC. The following section will interpret the analysis results using Model 2.

To further verify the robustness of these findings, this study conducted an additional analysis by

Table 4: The results of regression analysis

	(1) Model 1	(2) Model 2
Ordinary profit margin	0.1827*** (0.0325)	0.1782*** (0.0319)
Debt turnover period	-0.0768* (0.0449)	-0.0792* (0.0451)
Average total prime contract work completion value	-0.0045 (0.0050)	-0.0060 (0.0052)
Ratio of engineers	0.0012*** (0.0004)	0.0011*** (0.0004)
Winning bid rate		0.0502* (0.0270)
Constant	77.3001*** (0.3909)	72.8335*** (2.5075)
N	757	757
AIC	2261.768	2257.245

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

applying a natural logarithm transformation to the average total prime contract work completion value. This transformation accounts for the variable's skewed distribution (as evident from the descriptive statistics in Table 2, where the standard deviation is substantially larger than the mean) and potential non-linear relationships with construction quality. The results are presented in Table 5 (see Section A). In this specification, Model 1 shows that the ordinary profit margin and ratio of engineers remain positively significant, while the logarithm of average total prime contract work completion value emerges as positively significant. The debt turnover period is negative but non-significant. Model 2 yields similar patterns, with the ordinary profit margin, ratio of engineers and logarithm of average total prime contract work completion value positively significant; the winning bid rate is positive but non-significant. The AIC values indicate a slightly better fit than the original models, supporting the adoption of Model 2 here as well. Overall, the log transformation reveals a positive scale effect that was not apparent in the untransformed specification, while confirming the core relationships from the main analysis.

7. Discussion

The empirical findings align well with the theoretical predictions presented in Table 1, with all key variables showing their expected coefficient signs and achieving statistical significance.

Ordinary profit margin showed a significant positive association with quality; contractors with higher profit margins tended to record higher construction quality. This result is consistent with the results of Hatush and Skitmore (1997). Regarding RQ1, companies with good financial standing tended to have high construction quality evaluations. The following are considered to be the causes of this result. First, high profit margins create surplus funds that can be immediately devoted to additional on-site inspections and improvement activities. Second, fear of losses from lawsuits or bidding suspensions prompts management to engage proactively in preventing quality defects. Third, the desire to safeguard brand value and secure repeat orders motivates decisions that place quality first. Finally, profitable contractors can remunerate subcontractors fairly, enhancing the precision of material and schedule management. Collectively, these considerations are consistent with the observation that contractors with higher profitability are often associated with superior construction quality.

Regarding the debt turnover period, the results indicate that companies with greater financial soundness were generally associated with better quality, aligning with Hatush and Skitmore (1997). Regarding RQ2, companies with good financial conditions tended to have high construction quality evaluations. The following are considered to be the causes of this result. An extended debt-turnover period is typically associated with delayed cash realisation and increased cash-flow pressure, circumstances that may be linked to slower material purchases and payments to subcontractors, making deadline compliance and schedule coordination more difficult. Credit constraints imposed by financial institutions also deprive the contractor of the capacity to fund additional inspections. Further, payment delays erode the cash flow of partner companies, causing capable subcontractors to withdraw and degrading material quality. Such operational rigidity is often accompanied by reduced quality, increased rework and revisions, and ultimately lower levels of project completeness.

The average total prime contract work completion value had no significant effect; thus, it can be concluded that the business size does not affect the quality of the construction. This is consistent with Sekar et al. (2018), who found that business size does not affect construction quality. The fact that an average total prime contract work completion value did not lead to improved quality can be explained as follows. In construction, each project requires fresh procurement of labour and materials, so the amount of work completed seldom produces an internal learning effect that accumulates quality within the contractor. Furthermore, as contractors grow larger, their subcontracting chains become deeper and more multilayered, making it easier for quality standards to be diluted before they reach the lowest tiers.

However, the supplementary analysis using a logarithmic transformation of the average total prime contract work completion value alters this interpretation, revealing a significant positive association with construction quality (see Table 5 in Section A). This suggests that business scale influences quality in a non-linear manner: larger contractors tend to deliver higher quality, but the marginal benefit diminishes at higher scales, consistent with diminishing returns in resource allocation for quality assurance. The transformation likely addresses the variable’s right-skewed distribution, providing a more nuanced view. This finding contrasts with Sekar et al. (2018) but aligns with studies emphasizing scale economies in construction, where larger firms can leverage greater resources for quality control, such as advanced equipment or specialised teams (Gann, 1996). From a policy standpoint, this implies that very large contractors may have an inherent quality advantage, while mid-sized firms could benefit from targeted support to scale up effectively, potentially through incentives in pre-qualification systems.

The results showed that the ratio of engineers has a significant positive effect on quality. This is consistent with the results of studies by Doloi (2009), Enshassi et al. (2009), Jraisat et al. (2016) and Manoharan et al. (2022). They found that human capital management, such as the technical capabilities of contractors and the securing of engineers, significantly and positively impacted construction quality. Regarding RQ3, the construction quality evaluation tended to be higher for contractors with secured engineers. Gann (1996) compared the Japanese automobile industry with the prefabricated housing industry, indicating that, unlike the automobile industry, there is almost no standardisation of parts in the Japanese construction industry. These characteristics of the Japanese construction industry make quality control extremely difficult; however, this current study revealed that contractors with a competitive advantage in terms of technical capabilities, such as a high ratio of engineers, achieve high construction quality. The improvement in quality linked to a higher ratio of engineers can be attributed to the following. Construction sites differ in geology and climate, and their processes are inherently complex; therefore, the greater the number of engineers overseeing design and site management, the more readily specifications can be adjusted and safety measures implemented. In a multilayered subcontracting structure where skill levels vary, engineers can serve as hubs that disseminate and enforce standards, helping to prevent defects and improve precision—factors that appear to be associated with higher overall quality. For this reason, the government must move beyond simply supporting the training of highly skilled engineers and pursue reforms that embed technical competence more deeply in the public-procurement framework. Specifically, it should increase the weighting assigned to technical scores in bid evaluations and establish explicit minimum technical standards as entry requirements, preventing contractors that fall short from advancing to the price-competition stage. Such a design could restrain excessive price competition, make it possible to select contractors capable of guaranteeing high-quality construction, and may contribute to improved overall quality of public works. At the same time, upgrading technical skills is a task that each company must tackle proactively. By hiring more certified engineers, adopting cutting-edge ICT, and running their own training programs, contractors can steadily raise their technical scores at bid time. With higher scores, they gain an advantage over rivals even when offering similar prices, making technical improvements not just regulatory compliance but a strategic way to boost their chances of winning contracts.

The winning bid rate showed a significant positive association with the ACQE. This result is consistent with that of Jha and Iyer (2006). Regarding RQ4, when the competition for tenders is loose, there is a tendency for the construction quality evaluation to be high. Aoieong et al. (2002) pointed out that it costs money to maintain quality in the construction industry. Alsulamy (2022) also indicated that insufficient cost estimates at the planning stage can affect the failure of construction projects. When the winning bid rate is low, there is no room to pay for the cost of quality due to intense price competition; therefore, it is considered that the winning bid rate positively impacts quality. The link between a higher winning bid rate and better quality can be explained as follows. Contractors that win contracts at prices close to the target price have sufficient financial margin to absorb cost overruns, so they do not need to compress the schedule and can manage workflows more stably. This cushion lets them handle unforeseen ground-improvement work and quickly incorporate additional client requests or design changes on site. Securing a higher price also guarantees steady payments to subcontractors, which helps retain skilled craftsmen and ensures more rigorous quality inspections. Together, these factors create a virtuous cycle that raises overall construction quality. The results show that the winning bid rate significantly impacts construction quality; the policy implications are as follows. By introducing a low-bidding price investigation system and a lowest-limit price system, it is possible to prevent bidding at dumping orders and ensure a certain level of quality.

8. Conclusion

This study empirically analysed how the characteristics of contractors and winning bid rates affect the quality of construction projects in Japanese public works. The empirical analysis showed that companies with a high ordinary profit margin, a short debt turnover period, a high ratio of engineers, and a high winning bid rate had significantly higher construction project quality. In other words, the results indicate that the quality of construction projects tended to be higher for contractors with high profitability, financial soundness, and technical expertise. Furthermore, the quality of construction projects tended to be higher for contractors who won the bid at a price close to the target price.

This study has certain limitations. Due to the lack of data availability, the analysis is limited to contractors under the control of the Kanto Regional Development Bureau in Japan. More comprehensive research over a wider region will be necessary in the future. Furthermore, after March 2020, public works under direct national control were suspended in Japan in response to the spread of the COVID-19 virus. Thus, it is necessary to analyse whether such events affect the construction quality of construction companies. Furthermore, large-scale construction projects, such as the 2025 World Exposition and the Linear Chuo Shinkansen construction, are increasing, as is the demand for such projects. However, there are concerns about a shortage of construction workers due to issues such as the aging population. Thus, it is necessary to research construction quality, characteristics of contractors and winning bid rates over time in different macro environments. Profitability, financial soundness, construction scale, the proportion of technical staff, and the intensity of bidding competition are incorporated into the model as proxy variables that may influence construction quality. Nonetheless, the possibility remains that other factors also affect quality, indicating that additional control variables should, in principle, be introduced for a more refined analysis. Because identifying suitable control variables proved challenging, more comprehensive analyses and further model extensions are left as subjects for future research.

The novelty of this research lies in its use of quantitative data and statistical methods to demonstrate the relationship between the winning bid rate, characteristics of contractors and the quality of public works projects based on actual government agency construction quality evaluations and pre-qualification screening systems. The practical insights and contributions of this research are as follows. The results of this research suggest that construction quality can be improved by increasing the winning bid rate. In other words, the low-bidding price investigation system and the lowest-limit price system are meaningful for ensuring the quality of public works. Furthermore, this study revealed that the characteristics of contractors had an impact on the quality of construction. Therefore, the results suggest the significance of using the characteristics of contractors as criteria for selecting contractors in the design of the public works bidding and contracting system.

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A. Additional analysis

Table 5 presents the fixed-effects panel regression results using the natural logarithm of average total prime contract work completion value as a robustness check.

Table 5: The results of regression analysis

	(1) Model 1	(2) Model 2
Ordinary profit margin	0.1558*** (0.0327)	0.1517*** (0.0325)
Debt turnover period	-0.0487 (0.0463)	-0.0504 (0.0463)
Logarithm of Average total prime contract work completion value	1.0909** (0.4758)	1.0609** (0.4649)
Ratio of engineers	0.0020*** (0.0003)	0.0019*** (0.0002)
Winning bid rate		0.0409 (0.0271)
Constant	74.6373*** (1.1478)	71.0088*** (2.7484)
N	757	757
AIC	2253.460	2250.944

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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