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Detection of Unbalanced Bids: A Case Study

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Abstract

An unbalanced bid can be defined as a bid price that does not accurately reflect reasonable cost, contractor's profit, general overhead cost and other indirect costs. Selecting an unbalanced bidder as the contractor may lead to significant increases in the contract price. Therefore, detecting the unbalanced bids is a critical issue for owners. There are two main types of unbalanced bid, which consists of front-end loaded and quantity error exploitation. This study mainly focuses on the second type, namely quantity error exploitation, in which a contractor tends to increase the unit prices of items that are underestimated and reduce the unit prices of items that are overestimated because of errors in the estimated quantities. If an owner can detect the unbalanced bids during the awarding stage, a fair competition environment can be achieved. This study aims to provide owners with a model, which may assist them in detecting unbalanced bids. The proposed model uses five different grading systems. Owners may assign different weights to these grading systems and thereby the final score of each bidder can be calculated. All bidders can be evaluated based on the calculated final scores as well as the offered bid prices. The applicability of the proposed approach is demonstrated in an illustrative example. The findings of this study revealed that the proposed approach can be a useful tool for owners in detecting unbalanced bids.

Keywords: Unbalanced bid; detection model; grading system; owner; case study.

1. Introduction

Design-Bid-Build is the oldest, most familiar and traditional project delivery system in the construction industry. Although various alternatives (e.g., Design-Build, Professional Construction Management, etc.) to this project delivery system have been developed, it is still most commonly preferred by a great number of owners, particularly in the public sector. Construction projects built according to this project delivery system mainly undergoes five sequential phases: 1) pre-design phase, 2) design phase, 3) bid and award phase, 4) construction phase, and 5) post construction phase. In the bid and award phase, the owners aim to select the most appropriate contractors, who are capable of completing the project in budget, on time and at desired quality [1]. Therefore, this phase plays a key role in the project success.

One of the ways of gaining unfair competitive advantage against the rivals is proposing an unbalanced bid. Unbalanced bidding can be defined as manipulating the price of bid items without affecting the total bid price. Unbalanced bids are classified into two main categories, which include: 1) front-end loaded, and 2) quantity error exploitation. Front-end loaded unbalanced bidding has two types; front loading and end loading. Front-loading is the most common way to unbalance a bid. Front-loading refers to increasing unit prices of activities that need to be completed at the early stages in order to improve the contractor’s cash-in flow, while decreasing unit prices of activities that are to be completed in the later stages. End-loading is defined by inflating unit prices of late schedule activities. End-loading is used by some bidders to take advantage of escalation clauses in contracts. In quantity error exploitation, a bidder tends to increase unit prices of activities in which actual quantities are expected to exceed the estimated ones, whereas decrease unit prices of activities that are overestimated due to an error in estimated quantities stated in bid documents [2,3].

Unbalanced bidding is a commonly preferred strategy in unit price and lump sum contracts. In unit price contracts, unbalanced bids can be done by manipulating unit prices of items without affecting the total bid price [4,5]. In general, owners make the award decision based on the total bid price and do not pay much attention to variations in unit prices of items offered by different bidders. For this reason, it is more difficult to detect unbalanced bids created by quantity error exploitation for owners, especially in unit price contracts [3]. Therefore, this study focused on unbalanced bid created by quantity error exploitation in unit price contracts.

In the literature, there are numerous studies focusing on unbalanced bids in the construction industry. However, most of these studies have interested in developing optimization models to help contractors to win contracts and maximize profits of their bids, while offering the lowest potential bid price. On the other hand, limited models have been developed to help owners to detect and prevent unbalanced bids during the bid evaluation stage [4-7]. This study aims to provide owners with a model, which may assist them in detecting unbalanced bids. The proposed model uses five different grading systems. Owners may assign different weights to these grading systems and thereby the final score of each bidder can be calculated. All bidders can be evaluated based on the calculated final scores as well as the offered bid prices. In order to demonstrate how the proposed model can be performed in construction projects, an illustrative example is presented. The findings of this study revealed that the proposed model can help owners in detecting and preventing unbalanced bids during the bid evaluation stage.

2. The Concept of Unbalanced Bid

The idea of unbalanced bidding is not a new concept in the construction industry. Gates (1967) and Stark (1974) proposed effective studies on this phenomenon. Following these studies, numerous researches have been conducted to address unbalanced bids. Most of these studies represent a contractor's viewpoint on bid unbalancing. In many of them, models have been developed to help contractors in maximizing their profits while submitting the lowest possible bid price [8-11]. There are various disadvantages of unbalanced bids for owners. The most important ones are listed below [12-15]:

- Prevention of real competition environment,
- Risk of unbalanced bid being excluded in the bid evaluation stage, if it is detected by owner,
- Obligation of owner to pay in advance in unbalanced bid created by front-loading,
- Obligation of owner to pay more due to inflation in unbalanced bid created by end-loading,
- Failure of the lowest bid at the end of project,
- Ease of entry into the construction industry.

3. Detection and Prevention of Unbalanced Bids: The Developed Models

Owner efforts to detect unbalanced bids in advance as a preventive action because of its negative effects on the overall project performance. In the literature, there are limited studies that help owners in detecting and preventing unbalanced bids during the bid evaluation process. Unbalanced bids are not forbidden in the construction industry, but they are considered as unethical and risky strategy. If an owner has a mechanism to detect unbalanced bids, a fair competition environment can be created. Therefore, detection of unbalanced bids, especially quantity error exploitation, is a critical issue for owners. This type of unbalancing is much more difficult to detect than front-end loaded bids.

Bell (1989) proposed a single percentage factor method, which prevents unbalanced bidding in unit price contract. This method precludes quantity error exploitation bids and it also aims to prevent front-loading and end-loading of bid [16]. Wang (2004) developed an electronic based procedure to manage bid unbalancing in lump sum contracts. This method focuses on the adjustment of rates submitted by the lowest bidder in estimated quantities and the rates submitted by all qualified bidders without affecting the total bid price of bidder [17]. Arditi and Chotibhongs (2009) developed two separate processing models to detect front-end loaded and quantity error exploitation unbalanced bids. These models are based on comparing prices of each bid item with the engineer's estimates and the average prices offered by bidders [6]. Yin et al. (2010) stated that unbalanced bidding is a tool to win the contract with the lowest

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price for contractors. On the other hand, unbalanced bids may cause the low contract price but high project completion price. Therefore, their study provides the reference for owner's project investment control. Consequently, they recommend that unbalanced bid should be determined and eliminated by owner [14]. Renes (2012) suggested that unbalance bidding can be eliminated or mitigated by hiding quantities of activity estimated by owner. Renes (2012) also proposed that estimated quantities for each bid item may be presented to bidders as a range of values rather than as a single value [18]. Shrestha and Joshi (2012) conducted a linear correlation analysis to investigate whether bidders were applying front-end loading method [19]. Skitmore and Cattell (2013) presented a simulation study, which illustrates the likely impacts of using typical unbalanced bid detection methods under some assumptions [20]. Hyari (2015) proposed a model for prevention of unbalanced bids rather than detection. The model provides a systematic procedure, which uses the average unit price of all bidders to adjust unit price of every bid item submitted by each bidder without affecting the total bid amount of the bidder [4]. Hyari et al. (2016) presented a detection model to help owners in detecting unbalanced bids. The proposed model is based on considering uncertainty in estimated quantities of activity in order to detect unbalanced bids in the bid evaluation stage. The model uses Monte Carlo simulation to measure the risk impacts of differences between actual quantities of activity and estimated quantities to evaluate submitted bids [5].

4. The Proposed Unbalanced Bid Detection Model

This study aims to provide owners with a model, which may assist them in detecting unbalanced bids. For this purpose, the existing models were reviewed. The proposed model uses five different grading systems. Owners may assign different weights to these grading systems and thereby the final score of each bidder can be calculated. All bidders can be evaluated based on the calculated final scores as well as the offered bid prices. The five different grading systems in the proposed model are explained briefly in the below:

First grading system: The main idea behind this grading system is to compare the ratio of each activity's total price in the bid price offered by each bidder with the one estimated by the owner. From the bidder's viewpoint, the price of each activity i (i=1,2…n) is calculated multiplying its quantity (q_i) by its unit price estimated by the bidder (bup_i). From the owner's viewpoint, the price of each activity i (i=1,2…n) is calculated multiplying its quantity (q_i) by its unit price estimated by the owner (oup_i). The bid price (BP) is the sum of prices of every activity estimated by bidders (Eq. 1), whereas the estimated construction cost (ECC) is the sum of prices of every activity estimated by owner (Eq. 2). The ratio of each activity's total price estimated by each bidder in the bid price (br_i) and the ratio of each activity's total price estimated by the owner in the estimated construction cost (or_i) are calculated using Equations 3 and 4. Then the comparison ratio for the first grading system (r_1) is calculated by dividing br_i by or_i (see Eq. 5). Having calculated this comparison ratio, a grade is given to each activity (g_{1i}) based on the intervals given in Table 1. The total score obtained from the first grading system (BTS_1) is calculated using Eq. 6, where g_{max} is the maximum value of the grading system 1 (g_{max}=42).

$$BP = \sum_{i=1}^{n} bup_i \times q_i \tag{1}$$

$$ECC = \sum_{i=1}^{n} oup_i \times q_i \tag{2}$$

$$br_i = \frac{bup_i \times q_i}{BP} \tag{3}$$

$$or_i = \frac{oup_i \times q_i}{ECC} \tag{4}$$

$$r_1 = \frac{br_i}{or_i} \tag{5}$$

$$BTS_1 = \frac{\sum_{i=1}^{n} br_i \times g_{1i}}{g_{\max}} \times 100 \tag{6}$$

Second grading system: The main idea behind this grading system is to compare the unit price of each activity *i* (bup_i) offered by each bidder with the ones estimated by the owner (oup_i). In this grading system, the comparison ratio (r_2) is calculated using Eq. 7. Bidders obtain a grade for each activity (g_{2i}) based on the intervals given in Table 1. The total score received from the second grading system (BTS_2) is found using Eq. 8, where g_{max} is the maximum value of the grading system 2 (g_{max}=42).

$$r_2 = \frac{bup_i}{oup_i} \tag{7}$$

$$BTS_2 = \frac{\sum_{i=1}^{n} br_i \times g_{2i}}{g_{\max}} \times 100 \tag{8}$$

Third grading system: The main idea behind this grading system is to compare the unit price of each activity (b_{upi}) offered by each bidder with the average of unit prices (aup_i) offered by *n* number of bidders. The average unit price of each activity is calculated using Eq. 9 and the comparison ratio (r_3) is calculated using Eq. 10. Bidders obtain the grade (g_{3i}) according to the comparison ratio obtained for each activity (see Table 1). Then, the total score received from the second grading system (BTS_3) is found using Eq. 11, where g_{max} is the maximum value of the grading system 3 (g_{max}=42).

$$aup_i = \frac{bup_1 + bup_{2+} ... + bup_n}{n} \tag{9}$$

$$r_3 = \frac{bup_i}{aup_i} \tag{10}$$

$$BTS_3 = \frac{\sum_{i=1}^{n} br_i \times g_{3i}}{g_{\max}} \times 100 \tag{11}$$

Fourth grading system: The main idea behind this grading system is to compare the bid price offered by the bidder (*BP*) with the estimated construction cost (*ECC*). The comparison ratio (r_4) is calculated by Eq. 12. Bidders obtain the grade (g_4) according to this ratio based on the intervals presented in Table 2. The total score for grading system 4 (BTS_4) is calculated using Eq. 13, where g_{max} = 21.

$$r_4 = \frac{BP}{ECC} \tag{12}$$

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$$BTS_4 = \frac{g_4}{g_{\max}} \times 100 \tag{13}$$

Fifth grading system: The main idea behind this grading system is to compare to the sum of total prices of activities whose quantities may likely increase during the construction phase offered by bidders (br_{is}) with the ones estimated by the owner (or_{is}) (see Equations 14-15). The comparison ratio (r_5) is calculated by Eq. 16. Bidders obtain the grade (g_5) according to the comparison ratio presented in Table 1. The total score for the grading system 5 (BTS_5) is calculated using Eq. 17, where $g_{max} = 42$.

$$br_{i_s} = \frac{bup_{i_s} \times q_{i_s}}{BP} \tag{14}$$

$$or_{i_s} = \frac{op_{i_s} \times q_{i_s}}{ECC} \tag{15}$$

$$r_5 = \frac{br_{i_s}}{or_{i_s}} \tag{16}$$

$$BTS_5 = \frac{g_5}{g_{\max}} \times 100 \tag{17}$$

Table 1. Grade values for grading system 1, 2, 3 and 5.

Comparison Ratio	Grade	Comparison Ratio	Grade	Comparison Ratio	Grade
$r \le 0.9$	42	$0.965 < r \le 0.970$	28	$1.035 < r \le 1.040$	14
$0.900 < r \le 0.905$	41	$0.970 < r \le 0.975$	27	$1.040 < r \le 1.045$	13
$0.905 < r \le 0.910$	40	$0.975 < r \le 0.980$	26	$1.045 < r \le 1.050$	12
$0.910 < r \le 0.915$	39	$0.980 < r \le 0.985$	25	$1.050 < r \le 1.055$	11
$0.915 < r \le 0.920$	38	$0.985 < r \le 0.990$	24	$1.055 < r \le 1.060$	10
$0.920 < r \le 0.925$	37	$0.990 < r \le 0.995$	23	$1.060 < r \le 1.065$	9
$0.925 < r \le 0.930$	36	$0.995 < r \le 1.000$	22	$1.065 < r \le 1.070$	8
$0.930 < r \le 0.935$	35	$1.000 < r \le 1.005$	21	$1.070 < r \le 1.075$	7
$0.935 < r \le 0.940$	34	$1.005 < r \le 1.010$	20	$1.075 < r \le 1.080$	6
$0.940 < r \le 0.945$	33	$1.010 < r \le 1.015$	19	$1.080 < r \le 1.085$	5
$0.945 < r \le 0.950$	32	$1.015 < r \le 1.020$	18	$1.085 < r \le 1.090$	4
$0.950 < r \le 0.955$	31	$1.020 < r \le 1.025$	17	$1.090 < r \le 1.095$	3
$0.955 < r \le 0.960$	30	$1.025 < r \le 1.030$	16	$1.095 < r \le 1.100$	2
$0.960 < r \le 0.965$	29	$1.030 < r \le 1.035$	15	$1.100 < r$	1

Table 2. Grade values for grading system 4.

Comparison Ratio	Grade	Comparison Ratio	Grade
$r \le 0.950$	21	$1.005 < r \le 1.010$	10
$0.950 < r \le 0.955$	20	$1.010 < r \le 1.015$	9
$0.955 < r \le 0.960$	19	$1.015 < r \le 1.020$	8
$0.960 < r \le 0.965$	18	$1.020 < r \le 1.025$	7
$0.965 < r \le 0.970$	17	$1.025 < r \le 1.030$	6
$0.970 < r \le 0.975$	16	$1.030 < r \le 1.035$	5
$0.975 < r \le 0.980$	15	$1.035 < r \le 1.040$	4
$0.980 < r \le 0.985$	14	$1.040 < r \le 1.045$	3
$0.985 < r \le 0.990$	13	$1.045 < r \le 1.050$	2
$0.990 < r \le 0.995$	12	$1.050 < r$	1
$0.995 < r \le 1.000$	11		

A comparison rate is calculated for all grading systems. Bidders obtain grades according to these ratios. Grading tables (Tables 1 and 2) have been prepared so that bidders can be evaluated fairly. Two different grading tables were prepared within scope of the proposed model. Grading system 1, 2, 3, and 5 have a wide range, while grading system

4 has a narrow range. This indicates that grading system 4 is more sensitive than the others. In grading system 4, if the comparison rate is higher than 1.050, it gets the lowest grade ($g_{min}=1$), while if it is lower than 0.950, it gives the highest grade ($g_{max}=21$). This function also applies to the others, only the limit values are different.

Finally, different weights to these grading system can be assigned to calculate the final score of each bidder. The final scores of bidders are calculated using Eq. 18 and they are evaluated based on their final scores as well as the total bid price.

$$FS = w_1 \times BTS_1 + w_2 \times BTS_2 + w_3 \times BTS_3 + w_4 \times BTS_4 + w_5 \times BTS_5 \tag{18}$$

where w_1 is the weight for the first grading system, w_2 is for the second one, w_3 is for the third one, w_4 is for the fourth one, w_5 is for the fifth one.

5. Illustrative Example

In order to illustrate how the proposed model can be applied in construction projects, an example is presented. The presented example consists of 72 activities, 10 of which are related to groundwork, in other words, quantities of these activities may increase during the construction phase. The unit price of each activity estimated by the owner are taken from "The Construction and Installation Unit Prices Book" published by Ministry of Environment and Urban Planning in Turkey. 8 different bidders have been asked to propose unit prices for these activities. The units, quantities, unit prices of these 72 activities estimated by the owner (O) and proposed by 8 bidders (B) are presented in Table 3.

Table 3. Input data for illustrative example.

Act. ID	**Unit**	**Quantity**	**Unit Prices (TL)**								
			O	**B_1**	**B_2**	**B_3**	**B_4**	**B_5**	**B_6**	**B_7**	**B_8**
A_1	m^3	700	14.38	14.75	13.07	15.50	15.56	14.92	13.64	14.88	14.66
A_2	m^3	365	38.83	41.91	41.25	42.38	35.58	41.11	38.14	40.41	36.32
A_3	m^3	850	2.84	3.08	2.59	2.96	2.63	2.98	2.84	2.86	2.68
A_4	m^3	736	4.83	5.29	4.57	5.27	5.15	4.36	4.46	4.62	4.72
A_5	m	198	67.70	65.94	63.94	74.14	65.43	69.76	68.75	69.39	62.33
A_6	m^3	59	31.88	29.82	28.96	29.66	29.41	33.12	29.21	28.89	29.34
A_7	m^3	150	14.19	13.60	13.21	14.34	13.67	13.78	15.17	13.64	15.11
A_8	m^3	90	29.19	26.97	28.68	29.95	31.42	30.40	31.12	29.52	30.38
A_9	m^3	2000	178.63	170.44	183.53	173.77	166.04	189.94	187.99	175.84	169.66
A_{10}	m	1200	335.43	330.84	362.48	336.29	333.25	322.75	318.94	329.43	353.08
A_{11}	m	650	68.40	65.53	74.79	69.38	63.26	64.79	69.13	72.10	73.25
A_{12}	m^3	350	52.20	51.26	47.00	54.89	56.72	47.53	54.14	52.51	56.04
A_{13}	m^3	100	86.29	84.53	92.11	85.72	91.16	88.14	85.52	88.90	82.79
A_{14}	m^3	360	121.63	112.82	133.19	131.99	130.73	122.52	128.27	111.87	124.88
A_{15}	m	36	29.19	29.64	28.97	30.16	27.98	28.77	31.89	29.44	27.92
A_{16}	m	40	33.40	35.59	34.05	32.36	36.04	35.12	36.57	32.56	36.23
A_{17}	m^2	1000	22.18	20.98	23.41	20.95	23.78	22.35	23.19	23.00	20.95
A_{18}	m^2	750	23.24	23.34	21.41	23.86	21.85	21.32	24.63	21.88	22.87
A_{19}	m^2	635	31.39	32.96	31.66	29.76	30.56	32.36	28.90	29.47	33.33
A_{20}	m^2	400	35.64	36.75	37.55	36.58	39.03	35.38	37.56	35.40	36.21
A_{21}	m^2	348	38.05	39.78	38.77	39.28	35.44	35.79	39.19	39.63	35.08
A_{22}	m^2	250	50.16	50.34	49.73	52.14	45.85	52.27	49.12	50.30	49.46
A_{23}	m^2	100	26.56	26.26	27.36	26.88	25.07	24.98	27.50	24.59	27.82
A_{24}	m^2	150	35.63	36.26	34.12	37.72	34.84	35.66	35.98	32.82	35.03
A_{25}	m^2	75	23.61	24.87	21.25	21.81	24.29	23.15	23.41	24.72	24.89
A_{26}	m^2	98	28.59	25.89	26.65	28.53	28.52	31.41	28.69	28.21	30.46
A_{27}	m^2	50	27.29	27.41	25.95	29.84	26.82	28.77	25.32	25.65	24.73
A_{28}	m^2	43	29.98	30.20	29.84	27.50	30.75	28.48	32.57	28.26	30.09
A_{29}	m^2	66	44.61	45.92	47.46	44.67	40.65	48.92	42.76	43.53	41.53
A_{30}	m^2	40	58.94	54.01	56.03	53.11	59.19	59.65	54.99	59.98	60.40
A_{31}	m^2	40	39.54	43.20	42.80	39.07	37.86	38.69	42.66	41.16	39.66
A_{32}	m^2	100	40.24	42.55	39.59	41.02	42.52	43.04	41.36	41.56	36.69
A_{33}	m^2	450	1.94	1.75	2.08	2.01	1.94	2.00	1.99	2.01	1.75
A_{34}	m^2	350	2.35	2.17	2.48	2.39	2.27	2.55	2.20	2.58	2.19
A_{35}	m^2	40	16.91	15.70	15.29	15.72	16.19	15.85	15.66	16.05	17.10
A_{36}	m^2	60	20.71	18.91	20.89	20.97	20.51	21.01	22.31	20.95	20.96
A_{37}	m^2	50	14.68	15.50	14.91	13.82	13.55	13.29	14.37	14.57	13.84

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Table 3 (cont'd). Input data for illustrative example.

Act. ID	Unit	Quantity	Unit Prices (TL)								
			O	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
A_{38}	m^2	1000	27.71	26.86	27.56	26.32	29.55	26.55	26.78	27.64	28.43
A_{39}	m^2	450	43.24	39.04	46.78	45.19	46.00	43.59	45.01	45.12	47.13
A_{40}	m^2	900	32.39	34.31	29.90	34.25	33.58	32.77	29.28	31.71	29.34
A_{41}	m^2	650	33.90	33.90	30.71	36.87	36.48	30.83	35.46	31.94	31.03
A_{42}	m^2	100	6.29	6.84	5.71	6.33	5.92	5.68	5.97	6.86	6.02
A_{43}	m^2	1000	1.29	1.29	1.31	1.23	1.40	1.36	1.22	1.19	1.18
A_{44}	m^2	150	7.33	7.01	6.67	6.64	7.45	7.91	7.12	7.29	7.64
A_{45}	m^2	2000	11.78	11.58	12.45	11.39	11.86	12.38	11.66	12.90	12.94
A_{46}	m^2	1600	30.04	29.74	30.87	31.84	27.61	30.66	31.46	29.77	30.38
A_{47}	m^2	2000	29.56	30.55	30.33	30.01	32.43	28.17	30.23	29.49	27.07
A_{48}	m^3	600	4.59	4.65	4.72	4.72	4.68	4.50	4.27	4.87	4.15
A_{49}	m^3	450	5.84	5.36	6.42	5.29	5.88	6.11	5.41	6.06	5.64
A_{50}	m^2	750	4.83	5.29	4.61	4.97	5.18	4.77	4.79	4.86	5.21
A_{51}	m^2	1600	115.81	107.85	117.90	125.97	116.49	107.78	122.21	120.78	120.28
A_{52}	m^2	650	136.51	142.73	139.82	133.89	126.59	128.11	149.12	141.47	126.39
A_{53}	m^2	650	88.36	89.02	81.44	91.52	92.22	93.89	89.25	79.90	81.71
A_{54}	m^2	250	123.24	133.28	134.02	112.88	133.04	134.99	119.83	131.82	114.27
A_{55}	m^2	690	50.34	48.72	47.31	53.42	49.00	46.54	53.07	51.53	45.89
A_{56}	m^2	600	170.88	157.50	161.31	160.47	179.91	166.13	182.67	164.95	182.67
A_{57}	m^2	350	319.38	338.86	338.76	344.12	339.48	325.54	350.95	306.97	302.08
A_{58}	m^2	400	250.09	261.30	253.70	264.69	249.89	244.55	265.10	264.46	226.00
A_{59}	ton	1300	2096.56	2127.33	2152.31	1941.54	2089.57	2077.30	2026.49	1988.62	2045.57
A_{60}	ton	1650	2017.94	2140.37	2143.31	1877.71	1975.24	1998.95	1887.98	2160.53	1974.92
A_{61}	ton	350	1972.66	1871.37	1796.76	2120.92	2169.36	1789.12	2155.85	1837.37	1987.05
A_{62}	ton	1000	1939.23	1985.11	1832.36	1762.37	1999.50	2115.62	2044.00	1860.08	1918.36
A_{63}	ton	1150	1914.79	1914.13	1780.31	2038.14	1781.33	1987.31	1875.30	1810.11	1885.75
A_{64}	ton	200	3386.01	3642.50	3635.81	3425.98	3236.22	3658.23	3346.48	3591.23	3238.26
A_6	kg	4000	8.64	9.39	8.07	8.58	7.87	8.65	9.13	8.38	7.97
A_{66}	m^2	2000	9.59	9.16	10.29	10.06	9.74	10.16	9.55	8.82	10.51
A_{67}	m^2	600	13.00	12.96	13.32	14.30	14.00	13.68	11.84	12.36	14.07
A_{68}	m^2	150	5.23	5.62	5.34	5.53	5.32	5.06	4.91	5.17	5.45
A_{69}	m^2	2000	15.65	14.26	16.26	14.72	16.25	15.96	14.87	15.75	16.47
A_{70}	m^2	2000	18.56	19.20	16.81	18.13	19.78	18.95	17.37	17.73	18.78
A_{71}	m^2	700	28.60	27.78	27.36	26.28	31.23	30.24	27.97	27.13	28.49
A_{72}	m^2	2000	20.88	21.98	22.75	22.95	19.38	19.91	21.36	19.67	22.51

The estimated construction cost (*ECC*) estimated by the owner is 13,766,619.41 TL, and the bid prices offered by 8 bidders are 14,043,276.86 (BP_1), 13,826,569.14 (BP_2), 13,389,997.59 (BP_3), 13,624,850.19 (BP_4), 13,947,114.50 (BP_5), 13,622,893.85 (BP_6), 13,641,083.17 (BP_7), and 13,538,572.61 (BP_8), respectively. In this study, the weights are 20% for first grading system, 15% for the second one, 10% for the third one, 15% for the fourth one, and 40% for the fifth one. It should be kept in mind that these weights can differ depending on the needs of the owner. The final scores calculated for 8 bidders are presented in Table 4.

Table 4. Final scores of each bidder.

Bidders ID	Grad. Sys.#1 (20%)	Grad. Sys.#2 (15%)	Grad. Sys.#3 (10%)	Grad. Sys.#4 (15%)	Grad. Sys.#5 (40%)	Final Score	Ranking
B_1	61.71	52.74	39.12	31.82	50.00	48.94	6
B_2	58.84	56.31	45.27	50.00	66.67	58.91	2
B_3	57.99	68.34	59.75	77.27	2.38	40.37	8
B_4	59.25	64.84	53.22	63.64	54.76	58.35	3
B_5	61.14	54.01	42.19	40.91	42.86	47.83	7
B_6	58.83	64.07	53.38	63.64	52.38	57.21	4
B_7	57.67	62.71	52.26	59.09	38.10	50.27	5
B_8	60.07	67.24	57.40	68.18	61.90	62.83	1

Based on the final scores presented in Table 4, Bidder 8 (B_8) achieved the highest final score and Bidder 3 (B_3) achieved the lowest final score. Although B_3 offered the lowest bid price and received the highest grades from the second, third and fourth grading systems, it received the lowest final score because it received the lowest grade from the fifth grading system whose weight is the highest one. Consequently, B_3 achieved a very low score in the fifth grading system and this negatively affected the final score. On the other hand, B_8 is above average grade in all grading systems, although it does not offer the lowest bid price and has got the highest final score. Therefore, B_8 is the most appropriate bidder for the owner. It can be concluded that B_3 offers the most unbalanced bid, whereas B_8 offers the most balanced bid.

6. Conclusions

Unbalanced bidding is a major issue and an important unethical problem for owner in the construction industry. Owner has right to reject unbalanced bids, but it is hard to detect unbalancing because award decision depends on the total bid price and changes in unit price of bid items are usually not taken into consideration. For these reasons, it is more difficult to detect quantity error exploitation bids for owner, especially in unit price contracts. If an owner can detect an unbalanced bid, a fair competition environment can be created in the bidding process. This study focuses on quantity error exploitation bids in unit price contracts and aims to provide owners with a model, which assists them in detecting the potential unbalanced bids. In order to achieve this objective, the relevant literature was reviewed and then a model was proposed. The proposed model is designed to detect unbalanced bids by using five different grading systems. The final scores of bidders are calculated by assigning different weights to these grading systems. Bidders are evaluated according to their final scores as well as the total bid price. In order to demonstrate how the proposed model can be performed in construction projects, an illustrative example was presented. The outcomes of proposed model have shown that it is a useful tool for detecting unbalanced bids created by quantity error exploitation method in unit price contracts. This study also showed that when selecting the most appropriate contractor for project, owner should take into consideration not only bid price offered by bidders but also unit prices offered for each item. This study is limited as it only focuses on unbalanced bids created by quantity error exploitation method in unit price contracts. In future studies, the models addressing unbalanced bids in different types of contracts and created by front-end loading can be developed.

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