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Improved Unbalanced Bid Detection Model

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Abstract

Detection of unbalanced bids is crucial for owners because selecting an unbalanced bidder as the contractor may bring about cost overruns. There are two main types of unbalanced bids, namely, mathematically and materially unbalanced bid. This study mainly focuses on the second type, where a contractor tends to increase the unit prices of items whose quantity was somehow underrated by the owner's team. This study proposes a modification to a model that was developed to assist owners in detecting unbalanced bids. The major difference between the proposed model and the previous one lies in the grading system of detecting the unbalanced bids. In the proposed model, eight different grading systems are used in detection of unbalanced bids, whereas the previous model consisted of five grading systems. The final score of each bidder is calculated by assigning weights to these grading systems. Bidders are evaluated not only according to the offered bid prices, but also according to the calculated final scores. The applicability of the proposed approach is presented along with an illustrative example. It was observed that the proposed model detected the unbalanced bid, which attains the lowest final score. The proposed model represents a marked improvement on existing practice and provides owners with a new perspective in detecting unbalanced bids. Armed with such a tool, it may be easier for owners to protect themselves from the risk of unbalanced bids.

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

1. Introduction

Cost overrun is one of the main problems frequently encountered in construction projects [1]. From the owner's perspective, one of the effective ways to prevent cost overrun is to detect unbalanced bids during the bid evaluation phase. Manipulation of bid items' prices without changing the total bid price can be called as "unbalanced bidding" [2]. There are two main methods of unbalancing a bid: mathematically (front-end loading) and materially (quantity error exploitation) [3, 4]. Front-loading is a method that increases the unit prices of the activities scheduled to start in the early phases of the project while reducing the unit prices of the activities scheduled to start in the later phases. Thus, contractors can achieve better cash flows and higher profits while reducing their financial risks in the project [3]. End-loading is a method that is applied by increasing unit prices of activities in the later phases of the project. End-loading is a less-used method compared to front-loading. End-loading method is usually used for taking advantage of the escalation in countries with high inflation rates [4]. Quantity error exploitation is a method applied by increasing the unit prices of the activities in which actual quantities are expected to exceed the estimated ones, while decreasing the unit prices of the activities that are overestimated [5].

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Unbalanced bidding in the construction industry have been discussed by several researchers thoroughly [3]. Although detecting unbalanced bids created by quantity error exploitation is more difficult for owners [6], and there are few studies that help owners to detect and prevent unbalanced bids, most of the studies in the literature are conducted from the perspective of contractors [2, 4-9]. Therefore, this study focused on the detection of unbalanced bids created by quantity error exploitation in unit price contracts. For this purpose, after reviewing the existing models in the literature, an advanced unbalanced bid detection model was proposed by improving the model developed by Polat et al., (2018) [10]. The proposed model uses eight different grading systems in detection of unbalanced bids, whereas the previous model consisted of five grading systems. Owners may assign different weights to these grading systems according to the characteristics of their projects. After assigning weights to the grading systems, the final scores of each bidder can be calculated. All bidders can be evaluated not only according to their bid prices but also according to the calculated final scores. An illustrative example is presented to check the applicability of the proposed model in construction projects. The findings of this study indicated that the proposed model provided a marked improvement compared to the previous model. It also provides owners with a new perspective in detecting unbalanced bids during the bid evaluation phase.

2. The Improved Unbalanced Bid Detection Model

The objectives of this study include: (1) defining new grading systems to extend the existing approach in detection of unbalanced bids, (2) validating the new grading systems through an illustrative example. In order to achieve these objectives, the model developed by Polat et al., (2018) was modified by adding new grading systems. For the new grading systems, major and minor bid items have been defined. If a bid item's total price is equal to or greater than five percent of the construction cost estimated (ECC) by the owner, this bid item called as a "major bid item". On the other hand, if a bid item's total price is less than five percent of the ECC, this bid item called as a "minor bid item". Polat et al., (2018) described the existing grading systems for detection of unbalanced bids. The modified approach proposed in this study adopts the same grading systems used by Polat et al., (2018), but the following grading systems are added for detection of unbalanced bids.

Sixth grading system: The main idea behind this grading system is to compare the unit price of each major activity i_{mj} (i_{mj} = 1, 2, …, n) ($bupi_{mj}$) offered by each bidder with the ones estimated by the owner ($oupi_{mj}$). The ratio of each major activity's total price (or_{imj}) estimated by the owner in the ECC is calculated using Equation 2. In this grading system, the comparison ratio (r_6) is calculated using Equation 1. Bidders receive a grade for each major activity (g_{6imj}) based on the intervals given in Table 1. The total score received from the sixth grading system (BTS_6) is found by using Equation 3, where g_{max} is the maximum value of the sixth grading system (g_{max} =42).

$$r_6 = \frac{bup_{i_{mj}}}{oup_{i_{mj}}} \tag{1}$$

$$or_{i_{mj}} = \frac{oup_{i_{mj}} \times q_{i_{mj}}}{ECC} \tag{2}$$

$$BTS_6 = \frac{\sum_{i_{mj}=1}^{n} (or_{i_{mj}} \times g_{6i_{mj}})}{\sum_{i_{mj}=1}^{n} (or_{i_{mj}}) \times g_{\max}} \times 100 \tag{3}$$

Seventh grading system: The main idea behind this grading system is to compare the unit price of each major activity (bup_{imj}) offered by each bidder with the average of unit prices (aup_{imj}) offered by n number of bidders. The average unit price of each major activity and the comparison ratio (r_7) are calculated using Equation 4 and 5, respectively. Bidders receive a grade (g_{7imj}) according to the comparison ratio obtained for each major activity (see Table 1). Then, the total score received from the seventh grading system (BTS_7) is found using Equation 6, where g_{max} is the maximum value of the seventh grading system (g_{max}=42).

$$aup_{i_{mj}} = \frac{bup_1 + bup_{2+} ... + bup_n}{n} \tag{4}$$

$$r_7 = \frac{bup_{i_{mj}}}{aup_{i_{mj}}} \tag{5}$$

$$BTS_7 = \frac{\sum_{i_{mj}=1}^{n} (or_{i_{mj}} \times g_{7 i_{mj}})}{\sum_{i_{mj}=1}^{n} (or_{i_{mj}}) \times g_{\max}} \times 100 \tag{6}$$

Eighth grading system: The main idea behind this grading system is to compare the ratio of sum of the major activities' total prices (br_{imj}) to that of minor activities (br_{imn}) with the ones (or_{imj}, or_{imn}) estimated by the owner (see Equations 7-8). The comparison ratio (r_8) is calculated by Equation 9. Bidders receive a grade ($g8$) according to the comparison ratio presented in Table 1. The total score for the eighth grading system (BTS_8) is calculated using Equation 10, where (g_{max} = 42).

$$br_{i_{mj}} = \sum_{i_{mj}=1}^{n} (bup_{i_{mj}} \times q_{i_{mj}}) \ , \ br_{i_{mn}} = \sum_{i_{mn}=1}^{n} (bup_{i_{mn}} \times q_{i_{mn}}) \tag{7}$$

$$or_{i_{mj}} = \sum_{i_{mj}=1}^{n} (oup_{i_{mj}} \times q_{i_{mj}}) \ , \ or_{i_{mn}} = \sum_{i_{mn}=1}^{n} (oup_{i_{mn}} \times q_{i_{mn}}) \tag{8}$$

where q_{imj} is the quantity of major activity i_{mj} and q_{imn} is the quantity of minor activity i_{mn}.

$$r_8 = \frac{(br_{i_{mj}} \div br_{i_{mn}})}{(or_{i_{mj}} \div or_{i_{mn}})} \tag{9}$$

$$BTS_8 = \frac{g_8}{g_{\max}} \times 100 \tag{10}$$

For all grading systems, a comparison rate is calculated. Bidders receive grades depending on these ratios. The grading table (Table 1) allows the owner to evaluate the bidders objectively. In grading systems 6, 7, and 8, a comparison rate that is higher than 1.050 corresponds to the lowest grade (g_{min}=1), whereas a comparison rate lower than 0.950 corresponds to the highest grade (g_{max}=42). Finally, each bidder's final score can be calculated by assigning weights to each grading system according to a preferred criterion (Equation 11). The evaluation of the bidders will be based on these final scores.

$$FS = \sum_{j=1}^{8} (w_j \times BTS_j) \tag{11}$$

where w_j is the weight for the j^{th} grading system and BTS_j is the total score for the j^{th} grading system.

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Table 1. Grade values for grading system 6,7 and 8.

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

3. Illustrative Example

An illustrative example used by Polat et al., (2018) is presented to validate the applicability of the proposed model in construction projects. The presented example compromises 72 activities, and 5 out of 72 activities are identified as “major activities” while others are identified as “minor activities”. The unit price of each activity estimated by the owner are taken from “The Construction and Installation Unit Prices Book” published by the Turkish Ministry of Environment and Urban Planning. The units, quantities, unit prices of these 72 activities estimated by the owner (O) and offered by 8 bidders (B) are presented in Table 2.

Table 2. Input data for illustrative example.

Act. ID	Unit	Quantity	Unit Prices (TL – Turkish Liras)								
			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

Table 2 (cont’d). Input data for illustrative example.

Act. ID	Unit	Quantity	Unit Prices (TL – Turkish Liras)								
			O	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
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

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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
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 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 TL (BP_1), 13,826,569.14 TL (BP_2), 13,389,997.59 TL (BP_3), 13,624,850.19 TL (BP_4), 13,947,114.50 TL (BP_5), 13,622,893.85 TL (BP_6), 13,641,083.17 TL (BP_7), and 13,538,572.61 TL (BP_8), respectively. The weights assigned to grading systems are different from the weights used in Polat et al.'s (2018) study due to the addition of three new grading systems to the proposed model. In this study, weights were assigned as 15% for first grading system, 10% for the second one, 5% for the third one, 10% for the fourth one, 30% for the fifth one, 5% for the sixth one, 5% for the seventh one, and 5% for the eighth one. The owner can assign weights to each grading system according to the project characteristics. The ranking of the bidders according to the final scores is presented in Table 3. Based on the results presented in Table 3, Bidder 2 (B_2) has the highest final score, whereas Bidder 1 (B_1) has the lowest final score. Although B_3 offered the lowest bid price, it is ranked sixth according to the final scores. Moreover, B_1 has the lowest final score while offering the highest bid price. Finally, B_1 submits the highest bid price and the most unbalanced bid, whereas B_2 submits the most balanced bid despite not offering the lowest bid price. In other words, B_2 is the most appropriate bidder for the owner. The findings of this study reveal that the improved model provided a different ranking of bidders than the one obtained by Polat et al.'s (2018) model.

Table 3. Rankings of the bidders.

Proposed Models \ Bidders	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8
Previous unbalanced bid detection model *	6	2	8	3	7	4	5	1
Improved unbalanced bid detection model	8	1	6	4	7	3	5	2

* The model developed by Polat et al., (2018).

4. Conclusion

The main aim of this study is to propose an improved version of the unbalanced bid detection model developed by Polat et al. (2018). The proposed model uses eight different grading systems. Owners may assign weights to each grading system according to the characteristics of their projects. After assigning weights to each grading system, the final scores of bidders can be calculated. All bidders can be evaluated not only according to the offered bid prices but also according to the calculated final scores. An illustrative example is presented to validate the applicability of the proposed model. It was observed that the improved model detected the unbalanced bid but provided a different ranking of bidders than the one obtained by Polat et al.'s (2018) model. However, 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 model can be developed so that it can deal with the detection of unbalanced bids created by different methods.

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