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SELECTION CRITERIA AND TENDER EVALUATION: THE EQUIVALENT TENDER PRICE MODEL (ETPM)

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Abstract
Several research studies have identified critical success factors and their impact on project success. Central to both success and failure is the issue of selection criteria, and the importance of incorporating qualitative factors when contracting for complex design and construction projects. Empirical findings suggest that price is still commonly used criterion for selecting a winner, even though tendering documents indicate that quality factors are part of the evaluation. In this paper we argue that tender competitions with high focus on price in complex design and construction projects deteriorate both incentives for collaboration and project outcome in terms of cost and quality. Thus, the lowest bid may paradoxically result in the most expensive project from both an investment and a life cycle cost perspective. We offer an alternative approach to evaluating tenders, based on the Equivalent Tender Price Model (ETPM). The aim is to increase the probability of avoiding project failure related to cost overrun, poor quality and lack of functionality, in addition to ensure more transparency in the tender evaluation process. Simulation tests of the model demonstrate that evaluation of tenders through an Equivalent Tender Price model makes selection criteria more transparent and quantifiable and therefore less at risk of manipulation.

Keywords: Equivalent Tender Price, selection criteria, evaluation models, LCC, PDCS

INTRODUCTION

Several research studies have identified critical success factors and their impact on project success (see e.g. Belassi and Tukel, 1996; Fortune and White, 2006; Park, 2009; Pinto and Slevin, 1988; Zwikael and Globerson, 2006). Central to success is the factor of quality, operationalized as e.g. availability of required technology and expertise, technical background of contractor's personnel, and communication skills. Empirical research also identifies central determinants of project failure (Meland, 2000). These *failure factors* include the use of price competition on complex design services, poor communication and information logistics, as well as lack of competence. Common to both failure and success factors in construction projects is the importance of quality-based selection criteria when contracting for complex design and construction projects. The problem is that tender competitions with high focus on price in complex design and construction projects deteriorate both incentives for collaboration and project outcome in terms of cost and quality. Thus, the lowest bid may paradoxically result in the most expensive project from both an investment and a life cycle perspective. An increasing focus on environmental sustainability and life cycle costs in construction projects necessitates a new form of competence in the planning and management of construction projects, which in turn needs to be reflected and incorporated into the selection model. Recent practices of project management, however, emphasize qualitative aspects in the selection of contractors such as key personnel, past project performance, company standing (reputation), and technical expertise (Watt, Kayis and Willey, 2010). But the emphasis on soft factors increases the complexity of evaluation due to subjectivity and lack of transparency in the selection process.

Despite numerous efforts to establish a universal set of selection criteria, the issue continues to plague both theory and practice (Holt, 2010; Watt et al., 2009). The failure to develop such universal methods and criteria can be attributed to the complex circumstances of project contracting; the combination of soft and hard objectives, coupled with a large doze of uncertainty and risk. Even though mainstream literature is turning focus in criteria selection from "lowest price" to "value enhancement", anecdotal evidence suggest that price is still a commonly used criterion for selecting the winner. The gap between theoretical ideal and industry practice on criteria selection places a "credit crunch" (Holt, 2010, p. 305) on the "value literature". We offer an alternative approach to evaluating tenders, based on the Equivalent Tender Price Model (ETPM). The aim is to increase value enhancement for the client, by increasing the probability of avoiding project failure related to cost overrun, poor quality and lack of functionality, in addition to ensure more transparency in the tender evaluation process. In this paper we present and test the ETP model through simulation and compare the results to traditional selection models. The results demonstrate that evaluation of tenders through an Equivalent Tender Price model yields a result less at risk of manipulation in the selection process, because the selection criteria are transparent and quantifiable. The Equivalent Tender Price model is able to absorb and reflect the market price for qualitative elements such as competence and experience of key personnel, and should thus enable clients to make more correct decisions regarding price and quality in tender competitions.

CRITERIA FOR SELECTION

For any given project, it is essential to establish objectives and assess them according to how they influence the choice of project delivery and contract strategy (PDCS). This may include cost and schedule restrictions, as well as quality and business requirements (CII 2003; Lædre 2006). It is a crucial phase of the project process and encourages the client to focus on the critical success and failure factors for the project under consideration. Another central part of the PDCS is the selection of compensation forms, qualification criteria, selection criteria and the selection model itself. All these elements should represent choices that increase the probability of "best-value" for the client. Best-value contracting strategy aims at combining the use of price and qualitative factors in the qualification and selection process to enhance the long-term performance of the project. Among these are the criteria of reasonable whole life costing principles (WLC/LCC) and sustainability.

The importance of tender evaluation and selection criteria is well established in the project management and purchasing literature (Holt, 2010; Watt et al., 2010). Selection criteria and processes are directly related to project success and achievement of project objectives (Alsugair, 1999; Holt, Olomolaiye and Harris, 1994; Lopes and Flavell, 1998; Meland, 2000).

The success factors commonly focus on objectives such as availability of required technology, key personnel, expertise, technical background, and communication skills (Belassi and Tukel, 1996; Fortune and White, 2006; Park, 2009; Pinto and Slevin, 1988; Zwikael and Globerson, 2006). These are all indicators of "competence". Furthermore is past project performance, financial and technical capabilities, as well as tender price elements that are normally taken into the selection model. However, critical determinants in selection models have varied over time. Previous research point to price and cost as critical determinants of selection criteria (Hatush and Skitmore, 1997; Holt et al., 1994; Proverbs, Holt and Olomolaiye, 1997), whereas recent reviews contradict the findings from a decade earlier (see e.g. Holt, 2010). One study concludes that amongst 16 categories of selection criteria, price was found as the third lowest reported occurrence (Watt et al., 2009), even though anecdotal evidence and actual practice may point in a different direction. The increased value focus in tendering may partly be explained by the tendency of focusing more on life cycle cost and environmental sustainability, which in itself require a selection model that assess long term value rather than just the investments costs. Furthermore, the use of partnering models as well as collaborative contracting, necessitate more qualitative elements in the evaluation of tenders in order to reflect the participating parties' ability and incentives to cooperate, and to avoid sub-optimalization processes during the project.

Some of the traditional factors in tender evaluation should be taken care of outside the selection model itself, partly because they should not be exposed to competition, and partly because they are not acceptable criteria according to EU directives on public procurement (2004/18/EC 2004). The latter is a much debated issue within public procurement, because public clients commonly confuse qualification criteria with selection criteria. Even though they are closely related, there is a distinction between company capabilities in general and a company's bidding of specific personnel for a specific project. In the evaluation process it is therefore important to distinguish between qualitative factors that directly reflect value for a specific project, and qualitative factors that are merely an expression of the company's technological and financial capability.

Previous research on tendering competition of design services reveals two factors that should be avoided to circumvent project failure (Meland, 2000):

- too short time available for an adequate design process
- price competition on design services

To contest on time schedule in tender competition for design services jeopardizes the quality aspect of the design process itself, because a competition on the number of man hours and time factor in the design process represents a high risk for poor quality and costly changes in the construction phase. Unless time is an extremely important success criterion, it should be set up by the client as part of the project strategy aims and objectives. Due to economic incentives and EU procurement regulations, there should however be an element of price competition for design services. But in order to avoid the risk of inadequate design, these contracts should be reimbursable, and the tender price should focus on man-hour rates, which then is included in the selection model (Meland, 2000).

As previously pointed out competence is commonly viewed as a success factor for construction projects, and should therefore be an important criterion in any selection model for complex design and construction projects. Competence, however, is a typical proxy measure of quality which includes several indicators such as technical expertise and capability of key personnel. In the construction industry the problem with 'value enhancement' criteria is often that the qualitative elements either become too "costly" during the decision process, or they are not properly appreciated by the client, because the selection model can not absorb the quality differences between tenders. Suppliers of construction projects, who offer higher quality at the cost of higher price, run the risk of being discriminated *and* loose the bid, because the client is unable to assess the market price of quality in the selection model. The market price for competence is reflected in the average salaries for various levels of formal education and years of experience. Salary data may thus be used to estimate the price differences between different qualifications. Hence, in order to increase the markets' offering of higher competence levels in tenders, the client must be willing to pay for it. The suppliers must also be ensured that offering increased quality, through higher levels of competence, will be appreciated in terms of fair comparison of tenders. Finally, the "equivalent price" of each tender, on which comparisons are made, must reflect the value of quality in transparent and objective ways.

To establish incentives for offering increased quality at the cost of higher price, two factors must be attended:

1) The value of quality must be reflected and valued in the selection model
2) The selection model must have capacity to absorb differences in quality in a consistent way

The above factors are central elements in the ETP model as will be demonstrated in the following sections.

THE ETP MODEL VERSUS TRADITIONAL SELECTION MODELS

From an economic point of view, the theoretical problem in all selection models is the potential for adverse selection. This is especially a problem when the tender process involves qualitative elements, such as for instance supplier capability and competence. If hidden information exists about the suppliers' competence and no information is available for the client, price will be the only decision criteria. The risk of low price and low quality will be significant, and the client risks a suboptimal procurement situation. The issue of selection processes is to reveal relevant and trustworthy information about the supplier's and competencies. There may be two ways of acquiring such information. One is obviously to do the necessary research and gather relevant information about the different suppliers. But this may be both costly and possibly not very reliable data. The other way is through screening, by using relevant market information. Suppliers pay a market price for the staff employed. The price, as reflected in average market salaries, is based upon different employee characteristics. The salary can be interpreted as a hedonistic price function, because it is decomposed as a sum of values for the different characteristics; for instance formal education and years of relevant experience. By using the values for the different employee characteristics, observations can be made on how the market values these characteristics. This market information is valuable to reduce the risk of adverse selection and increase the probability of selecting the supplier offering the best combination of price and quality. In the following section we will illustrate this point by using the "equivalent tender price" (ETP) model. For comparison, we will first illustrate how a traditional selection model fails on three important issues. First of all a traditional model is usually linear, which delimits the model's mathematical capacity to absorb the variety of tender scores on selection criteria. Second, a linear model does not "act" in the interest of the client, and thirdly it does not reflect the marked pricing of competence. These weaknesses are illustrated in the sections below.

Selection criteria and corresponding measures
Common selection criteria for construction projects include a price element and one or more qualitative elements. Normally the client assigns weights to each element to reflect the client's emphasis on the different criteria in the model. Each tender receives a score per criterion, based on the client's evaluation of each tender. The final value for each bid in a linear selection model will be a sum of the weighted scores per criterion, where the winner has highest sum.

For illustration purposes, we first simulate results of a tender competition with a linear selection model. We then use the same simulation data in the ETP model and compare the results. The following selection criteria are used throughout the testing of the two models:

- Price
- Competence
- Other (project related criteria of importance)

In the model simulation our specific focus is on the price and competence criteria. However, we have included a third criterion, "Other", to illustrate the model's rest capacity to include other criteria in addition to price and competence. Each criterion is assigned an individual weight summarized to 1,0 (100 %). The weights are labeled as follows:

- V_1 = Price
- V_2 = Competence
- V_3 = Other

Each criterion can be divided into several indexes that are relevant and measurable. In this simulation we limit the use of indexes to the competence criterion, which is measured by following:

- V_{21}= Level of formal education (master, bachelor etc)
- V_{22}= Relevance of education compared to the actual project position and project
- V_{23}= Time of experience
- V_{24}= Relevance of experience compared to the actual project position and project

An individual score per tender will be assigned to each of the four indexes. The individual scores will range between 0,0 and 5,0 and is labeled as follows:

- m_{21} = Score on formal education, where Master of Science =5,0, Bachelor of Science =4,0, No formal education beyond high school=2,0. Scale interpolation is used for additional studies/courses etc.
- m_{22} = Score on relevance of education, where for instance a degree in architectural science yields top score (5,0) while a computer science degree yields a low score (1,0) in an architectural design competition
- m_{23} = Score on experience, where > 30 years of experience =5,0 and no experience = 0. Values are to be interpolated linearly between 0 and 5.
- m_{24} = Score on relevance of experience, where 3 relevant projects in the CV =5,0 and less relevancy is to be linearly interpolated towards 0.

Each candidate offered in the individual tender is rated according to the above indexes, and a weighted average score is calculated to reflect each tender's total score on V_2 Competence. Normally the market price for competence can be measured by the average salaries according to employee characteristics such as level of education and relevant experience. The association of chartered engineers in Norway (RIF) yearly presents statistics of salaries, invoicing level, different cost elements etc for their members. We use RIF statistics (2009/2010) to compare the marked value of three competence indicators:

- Formal education (V_{21}),
- Time of experience (V_{23}),
- Relevance of education and experience (V_{22} and V_{24} summarized).

Based on statistics from RIF (2010), table 1 presents simulated examples of yearly salaries for engineers. The other items included in the table are various costs and parameters associated with the corresponding salary level for engineers in Norway. From table 1 we find that an average salary for a Master of Science in engineering is priced to €85625 per year, and a Bachelor of Science degree is priced to €72875, which gives a difference of €12750. When controlling for all other parameters but formal degree, the equivalent market price of a Master of Science candidate is €111 per man-hour (mhr), whereas the man-hour rate for a Bachelor of Science candidate is €98. The difference in a company's bid price for these two candidates is €13 which represents the difference in marked price between the score 4,0 and 5,0 for the factor formal education (V_{21}) in our model.

			MSc candidate		BSc candidate		
Yearly salary	100 000	87 500	**85 625**	75 000	**72 875**	62 500	56 125
Manhour salary	57	50	49	43	42	36	32
Social costs (25%)	14	12	12	11	10	9	8
Company's salary cost	71	62	61	53	52	44	40
Invoicing level	73 %	73 %	73 %	73 %	73 %	73 %	73 %
Company's real cost	98	86	84	73	71	61	55
Overhead per manhour	18	18	18	18	18	18	18
Profit	9 %	9 %	9 %	9 %	9 %	9 %	9 %
Company's bid price	126	113	**111**	100	**98**	86	80

Table 1: *Salary and cost statistics for employment of different engineering candidates. All figures in € (based on statistics from RIF, 2010)*

According to the RIF statistics (2010) a yearly salary for a Master of Science degree varies on average from €59625 for a non-experienced master candidate, to €124125 for an employee with 30 years experience on top of her master degree. Corresponding figures for Bachelor degrees are €53375 and €81625, respectively. Thus on average for both categories this indicates that the marked price of one additional year of experience for an average engineer is close to €1,25 per man-hour. The scale interval for V_{23} (time of experience) represents 7,5 years. This corresponds to a market price difference of €9,12 per interval, which, all else equal, indicates the price difference between a candidate with 30 years and a candidate 22,5 years of experience. Finally, according to RIF, the salary gap between the group of highest paid engineers (measured as 90 % percentile) and the lowest paid engineers (measured as 25 % percentile, since 10 % not available), is on average for both masters and bachelors €18,75. This figure represents the full range of the scale for V_{24} and V_{22}, with a marginal change value of €4,75.

The salary data for Norwegian technical personnel is reliable for the characteristics V_{21} (Level of education) and V_{23} (Years of experience). There is, however, no salary information available for criteria V_{22} and V_{24}, which both relates to work-specific relevance of education and experience. As an approximation we have used a measure of the variation in salaries for these criteria. We assume that salary variation for engineers across all education and experience levels is partly explained by differences in relevant skills. This assumption is, however, highly debatable. The variation may also reflect different scarcities in different marked segments for technical personnel.

In the following illustrations he figures above are assumed to be the market price for the value of formal education (V_{21}), time of experience (V_{23}), relevance of education and experience (V_{22} and V_{24}). In the next section we test the general linear model and the ETP model, using estimated market values to demonstrate the difference in capacity and transparency between the two models.

Testing selection criteria in a linear model

A traditional way of calculating for the price score for a tender is to give the score 2,5 for the average priced bid, 0 for the highest bid and the score 5,0 for the lowest bid (score scale 0-5). The other bids' score are calculated linearly. Five bids with the illustrated man-hour rates and tender price in table 2 should then be given the following price scores:

Bids	A	B	C	D	F
Manhour rate and tender price (€)	100	106	113	119	125
Price score (m_1)	5,00	3,75	2,50	1,25	0,00

Table 2: *Five illustrated bids with linear score on price*

As illustrated in table 1, the marked price for an average master candidate is €111 and €98 for a bachelor candidate. All other factors equal, tenders based on these man-hour rates should be given equal score in any selection model, given that market value of competence is of importance for the client. We add these two "bids" to the 5 other bids in table 3 and start the selection process based on a linear selection model. Price is given the weight 25 % of total.

	BSc candidate			MSc candidate			
Manhour rate and tender price (€)	**98**	100	106	**111**	113	119	125
v_1 Price	0,25	0,25	0,25	0,25	0,25	0,25	0,25
m_1 Price score	5	4,57	3,43	2,54	2,29	1,38	0,00
v_{21} Formal degree	**0,62**	0,62	0,62	**0,62**	0,62	0,62	0,62
m_2 Degree score	**4**	4	4	**5**	5	5	5
v_3 Other criterion	0,13	0,13	0,13	0,13	0,13	0,13	0,13
m_3 Score other	5	5	5	5	5	5	5
Score total	**4,38**	4,27	3,99	**4,38**	4,32	4,09	3,75

Table 3: *Traditional linear selection model (Score= v1* m1 + v2* m2 + v3* m3)*

Table 3 demonstrates that by weighting the formal degree ($V_{21)}$ criteria 0,62, the two candidates (master and bachelor) obtain the same total score (4,38) as they should, according to the pricing of formal degree. All the other tenders are overpriced relative to the type of candidate offered. Their price score in combination with formal degree score is causing their tender loss. As shown, price (V_1) and formal degree (V_{21}) constitute a total of 87 % (0,62+0,25) out of the total model capacity. Thus the model is inadequate to absorb the full value competence as V_{22}, V_{23} and V_{24} are not included. Hence the linear model does not "act"

in the interest of the client, because it does not reflect the marked pricing of competence in its full scope, but reflects competence only through formal degree. Capacity constraints is one of the major weaknesses in traditional, linear selection models, and it jeopardizes possibilities for a more thorough and objective differentiation of qualitative aspects in bids.
We also observe another capacity weakness of the traditional model. By comparing table 2 and 3, we observe that the price score (m_1) given for the original five bids have changed as a consequence of adding the two new "bids". This indicates that the model is neither predictable nor robust. Linear selection models usually assign the price weight to be between 40 to 80 % of total criteria. This means that in practice the competition is almost solely based on price, even though the client may indicate otherwise in the tender documents. Furthermore, it is commonly observed that the full scale range for price is fully used (e.g. 0-5), but the scale range for other criteria is often used between 2 and 4. The real evaluation is thus even more price focused than exemplified above.

We have demonstrated that a linear selection model is very sensitive to the tender evaluation structure and in fact also to the numbers of tenders. This affects the model's robustness in an undesirable way. We suggest a solution to the problem by constructing a more robust and universal applicable model.

Testing selection criteria in the ETP Model

A main purpose in the ETP-model is to establish a useful and operational balance between the consideration of price and qualitative elements in selection models. Formally this is done by choosing one single parameter, k, in the ETP-model. The model is constructed in such a way that the value of k influences the client's choice of focus; from pure price competition to hardly any weight on price at all. A very large value of k represents pure price competition, whereas when k is reduced towards zero, more and more emphasis is placed on qualitative elements.
As the intention is to use market price information, the model has to be aligned to the observable market prices (salaries). We will demonstrate one way of doing this, and at the same time discuss various design of the model. We have argued that a linear selection model for projects where quality elements play a critical role is more or less useless. Instead we propose a quadratic model, and demonstrates its usefulness by simulate different values of the parameters for scores and weights. In these simulations we will be using market information for the salaries for technical skilled personnel in Norway (RIF, 2010).

The general formula for the ETP model we are going to use is (note its quadratic form):

$$ETP = P\frac{M^2 + k}{(\sum_i v_i m_i)^2 + k}$$

where:

ETP = Equivalent tender price
P = Estimated price inclusive of the suppliers profit
M = Maximum score on a selected scale (e.g. 5)
k = A selected constant as a number $[0,\infty)$
v_i = Weight of the quality factor i ($\sum v_i = 1$)
m_i = Score of the quality factor i (e.g. [1,5])

The sensitivity of ETP with respect to the choice of k, may be illustrated as the derivative of ETP with respect to k:

$$\frac{\partial ETP}{\partial k} = P\frac{\left((\sum_i v_i m_i)^2 + k \right) - \left(M^2 + k \right)}{\left(\sum_i v_i m_i)^2 + k \right)^2} \leq 0$$

If k is increased the ETP is reduced, so a higher k means less weight on the quality factors described by $\sum_i v_i m_i$. Furthermore as $k \to \infty$ $\frac{\partial ETP}{\partial k} \to 0$, which means that ETP is an asymptotic downward sloping function towards P. A simulation of ETP with different levels of scores on $\sum_i v_i m_i$ is shown in figure 1. In the figure, k varies between 0 and 100, and the maximum score is 5 so $M^2 = 25$. The figure illustrates the ETP when the estimated price =1 for suppliers scoring a $(\sum_i v_i m_i)^2$ of 5, 10, 15, 20 or 25.

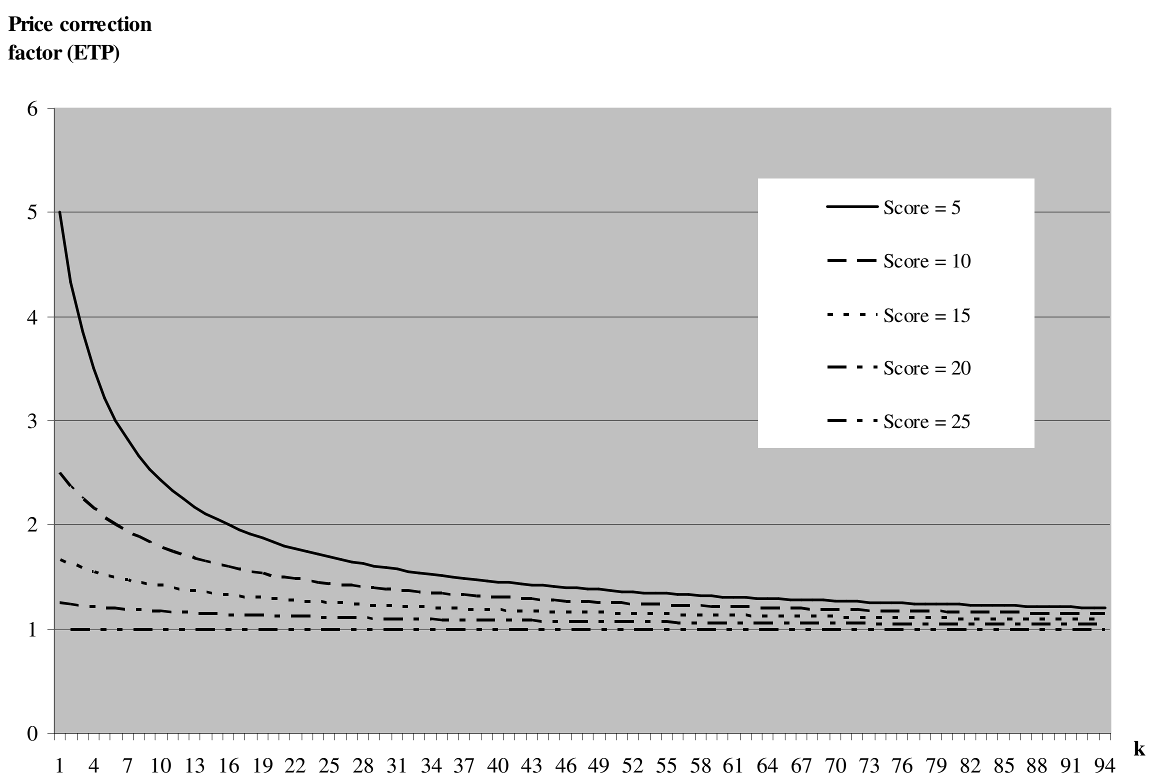

Figure 1: *Price correction factor (ETP) for different values of k*

Figure 1 shows the importance of selecting a low k if quality is the dominant selection parameter of a tender. Furthermore if there is a variety of selection parameters, a low k must be chosen to "make room" for aligning the model to market information, as will be demonstrated in the simulations in the next section. The quadratic model has the potential to discriminate between different suppliers more efficiently than a linear model as one can reduce k towards zero to exponentially increase the weight on quality. This will also be illustrated in the simulations in table 3 and 4. Figure 1 also demonstrates that by choosing a low k one harshly punishes law quality tenders as the difference between the ETPs increases progressively when the scores on $(\sum_i v_i m_i)^2$ declines.

The model incorporates both a price element and qualitative elements, as the aim is to give high score (yielding a low ETP) to tenders offering factors that increases the probability of avoiding project failure related to cost overrun, pure quality and lack of functionality. We aim for a model with few and simple quality factors, but with build-in capacity to open for use of supplementing factors. Furthermore, the ETP selection model will be able to incorporate relevant success-factors at their marked price, and balance price and qualitative elements in a way that reveals the best tender. Finally the ETP model allows the individual bids score to be independent of each other so every criterion in the model – even price – can be evaluated in a transparent way. Of course, to ensure transparency, the score scale and the individual weight for the selection criterions must be clearly defined in the tender papers and meticulously used in the evaluation process.

In the following we present a numerical example of using a non-linear ETP model. As demonstrated in table 4, the model is capable of absorbing 34 % of the total weighting for other criterion than competence (V_3) by using k=0.

Offered tender candidates	MSc candidate	BSc candidate	BSc candidate, w/less experience	BSc candidate, w/less experience and low relevance
Manhour rate and tender price (€)	**111**	**98**	**88**	**84**
M = Max score	5	5	5	5
k = constant [0,?)	**0**	**0**	**0**	**0**
v_{21} Formal degree	**0,32**	**0,32**	0,32	0,32
m_{21} Degree score	5	**4**	4	4
v_{22} Relevance of degree	0,00	0,00	0,00	0,00
m_{22} Relevant degree score	5	5	5	5
v_{23} Experience	0,23	0,23	**0,23**	0,23
m_{23} Experience score	5	5	**4**	4
v_{24} Project relevant experience	0,12	0,12	0,12	**0,12**
m_{24} Relevant experience score	5	5	5	**4**
v_3 Other criterion	0,34	0,34	0,34	0,34
m_3 Other criterion score	5	5	5	5
Equivalent Tender Price (ETP)	**111**	**111**	**111**	**111**

Table 4: *Examples of tenders evaluated by the ETP model with k=0*

In table 4 we present four tenders with different man-hour rates and different competencies of the candidates offered. A fully experienced (30 years or more) MSc candidate with relevant project experience (3 or more) has a tender price of €111. A fully experienced BSc candidate with relevant project experience is offered at €98. However, a BSc candidate with only 22,5 years of experience, but with full relevant project experience is offered at €88. Finally a BSc with 22,5 years of experience, and less relevant project experience is priced to €84. All these tenders should be evaluated equally valuable for the client, given equal score on parameter V_3 (other criterion). They are all priced according to marked value for the individual competence factors V_{21} – V_{24}. Thus the equivalent tender price illustrates how a high priced tender with a fully experienced and qualified master is valued equal to a low priced tender offering a bachelor candidate with 22,5 years of experience and less relevant project experience.

In table 5 we present the same tenders as in table 4, but k=5 is used instead of k=0. As illustrated in the table, the model capacity is reduced by increasing the value of k. There is only about 20% left for other criteria than competence. This demonstrates that for tenders of design and design build contracts, where competence is an important economic factor, k should be set low in order to fully take advantage of what the market can offer.

Offered tender candidates	MSc candidate	BSc candidate	BSc candidate, w/less experience	BSc candidate, w/less experience and low relevance
Manhour rate and tender price (€)	111	98	88	84
M = Max score	5	5	5	5
k = constant [0,?)	**5**	**5**	**5**	**5**
v_{21} Formal degree	**0,38**	**0,38**	0,38	0,38
m_{21} Degree score	5	**4**	4	4
v_{22} Relevance of degree	0,00	0,00	0,00	0,00
m_{22} Relevant degree score	5	5	5	5
v_{23} Experience	0,28	0,28	**0,28**	0,28
m_{23} Experience score	5	5	**4**	4
v_{24} Project relevant experience	0,15	0,15	0,15	**0,15**
m_{24} Relevant experience score	5	5	5	**4**
v_3 Other criterion	0,20	0,20	0,20	**0,20**
m_3 Other criterion score	5	5	5	5
Equivalent Tender Price (ETP)	**111**	**111**	**111**	**111**

Table 5: *Examples of tenders evaluated by the ETP model with k=5*

We recommend k=0 for tenders of complex to middle complex design services. More simulations, however, are needed in order to qualify for recommendations in pure construction contracts.

CONCLUSION

The ETP-model has, with different values of the *k* factor, been used in proximately 20 tender competitions in Norway. For every competition the score scale and the individual weights of the chosen selection criteria have been defined in details and strongly adhered to in the evaluation process. The evaluation of competence has thus been fairly simple and transparent. The use of other criteria, such as process understanding, project manning plans, and team management with client and users etc., have been given a wide range of scores, which is an indication of measurement problems and low predictability.

Commonly used models and criteria for selection of tenders are still highly focused on price, even though literature indicates a turn of focus from lowest cost to value enhancement in complex construction projects. The important issue, however, is how traditional selection models are capable of including the value of qualitative elements, of for instance competence, as reflected by the market price.

We have demonstrated that traditional linear selection models do not have the capacity to absorb the market's pricing of competence in tender competition for consultancy services and complex construction projects. We therefore offer an alternative approach to evaluating tenders, based on the Equivalent Tender Price Model (ETPM). The aim is to increase the probability of avoiding project failure related to cost overrun, poor quality and lack of functionality, in addition to ensure more transparency in the tender evaluation process. Simulation tests of the model demonstrate that evaluation of tenders through an Equivalent Tender Price model makes selection criteria more transparent and quantifiable, and therefore less at risk of manipulation. Furthermore the ETP model demonstrates more robustness with respect to adding more qualitative elements into the model. The model is also capable of reflecting marked prices for services irrespective of other tenders, as well as encountering new bids without having to alter the pre-assigned weights.

Our simulations of the ETP model conclude that competence should be given a weight of 66 – 81 % of total weighing in the model, depending on the value of k (0-5). How competence should be weighted for pure construction contracts is dependent upon the specific contract strategy, further studies of the market's pricing of the competence profile in construction companies, and the fact that engineers are representing approximately 10-20 % of total construction costs. A tender competition for a design-built contract should yield higher competence weighting than a pure built (design-bid-built) contract, and the uncertainty and complexity should be taken into consideration. The choice of the constant k in the ETP model will balance these considerations.

LIMITATIONS AND FURTHER RESEARCH

We have argued that the ETP-model is more robust and universal applicable than e.g. a linear selection model. This does not however mean that the weights and scores used in our example are applicable in every situation. For different purposes and especially for different countries, it may be useful to align the scores and weights according to for example the country specific conditions. For the competence criterion, different countries may have different educational systems which may justify other grades of the scores.

Future research should seek to remedy these limitations by providing greater empirical evidence of the robustness of the model.

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