Supplier selection requires full transparency

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Abstract

In this paper, we highlight a number of problems arising with a commonly used supplier selection method: the weighted factor score method. We discuss the behavior of this method with respect to weighting, scaling issues, and relative scoring. Assuming that there is no convex dominance, we formally prove that with the same supplier selection method, we can make any supplier win by judiciously choosing the right parameters of the awarding mechanism. This means that any supplier can win if certain parameters are not published in a request for a proposal. This result applies to both absolute and relative scoring methods. Also, we show that the buyer should fully disclose all details of the awarding mechanism to suppliers in order to get better bids. The practical implications of our results are far reaching for (public) procurement: full transparency and disclosure of all details of weights and awarding schemes is not only required to avoid subjectivity in supplier selection, but it also leads to better bids from suppliers.

Key words: Supplier selection; transparency; purchasing

Introduction

Supplier selection has attracted quite some attention from academics. Possible reasons for this are its perceived importance, its visibility (at least in the sense that the ultimate outcome is identifiable), and its suitability for formal, mathematical modeling. Many academic papers describe various formal decision methods, decision elements, supplier behavior in tendering, and quantitative and qualitative decision criteria for supplier selection (e.g., Albano et al., 2008; De Boer et al., 1998, 2001; De Boer and Van der Wegen 2003; Choi and Hartley, 1996; Munson and Rosenblatt, 1997; Narasimhan, 1983; Weber and Current, 1993).

In addition to this academic attention, quite some attention has been paid to supplier selection by governments and legal experts. For instance, the European Union (EU) directives state that to enhance transparency, objectivity, and non-discrimination, tendering organizations should publish (1) the decision criteria and (2) their relative importance (if applicable) in a Request for a Proposal (RfP).

Despite this amount of attention from academia, public policy makers, and practitioners, the practical use of formal decision methods is not without problems and misuse. This can be explained by the fact that many aspects play a role in supplier selection and many decision criteria and methods can be considered, whilst the effects of these methods are not always known. As a result, many organizations, especially in the public sector when trying to identify an Economically Most Advantageous Tender (EMAT), struggle with the pressure to explain

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their supplier selection choices (De Boer et al., 2006). Therefore, we argue that it is important to gain a deeper understanding of the practical features and dynamics of commonly used supplier selection methods.

Using mathematical proofs, our research objective is to determine the scope of a number of problems arising with commonly used supplier selection methods in the public sector to identify an EMAT. In particular, we explore when and what can happen if decision criteria and their weights are published, but other parameters of the awarding mechanism – that are not mentioned in the EU directives – are not published in an RfP. Under a rather mild assumption, we show that every supplier in a tender can win if specific details of the awarding mechanism can be determined after the fact. We also show that it is theoretically optimal for the buyer to fully disclose all details of the awarding mechanism to suppliers.

The paper makes a novel contribution in two ways. First, our paper extends beyond the existing literature by providing formal mathematical proofs of the problems that may occur in applying common supplier selection methods. We also show what the effects of full transparency can be. Based on our first contribution, we provide insights for (public) procurement practitioners seeking to apply a supplier selection method.

The paper is organized in the following way. First, we use an example from practice to introduce our main research question. Second, we provide our main analysis and proofs on how we can make any supplier win a tender. Next, we show and analyze some extensions and practical implications of our proofs. The last sections discuss the limitations and some conclusions.

A supplier selection case

We introduce our supplier selection model using a simple example. In this example, there are two decision criteria, namely price (p_i for each supplier i) and quality (q_i for each supplier i). In our example, we measure quality in delivery time. Weights w_j for each criterion j are chosen to reflect the relative importance of the criteria. Here, quality is considered to be more important than price. Accordingly, the details of the awarding mechanism are published in an RfP as shown in Table 1.

Supplier i (weights w_j)	Price p_i (40%)	Quality (delivery time) q_i (60%)

Table 1: A supplier selection example

In this paper, we consider the well-known and widely used Weighted Factor Score (WFS) method as a supplier selection method. In WFS, all suppliers are awarded scores on all criteria. These scores are multiplied (weighted) with the respective weights of the criteria and for each supplier i the total score is defined as WFS_i. The supplier with the highest total score is awarded the contract. In the RfP, it is published that WFS is used as a selection method, but the scoring methods are not published.

In Table 2, the details of the supplier bids are given.

Supplier i (weights w_i)	Price p_i (40%)	Quality (delivery time) q_i (60%)
Supplier 1	€ 4,200	18 weeks
Supplier 2	€ 4,500	15 weeks
Supplier 3	€ 4,750	13 weeks

Table 2: A supplier selection example with supplier data

The scores on the criteria can be calculated by the buyer by various scoring methods. We classify these methods in absolute and relative methods. The calculations in relative methods depend on the best, worst and/or average supplier bids, while the calculations in absolute methods are independent of the other supplier bids.

Both absolute and relative scores can be detailed in various ways. For example, the parameters used in their formula may be chosen by the buyer as well as the form of the graphs involved: linear or curved (and of course, also what kind of curvature).

In our example, the weighted scores on price range from 0 to 40 points. Below, we give a few examples of formula to calculate the scores:

- An absolute linear score: $AL_i(p) = 40 - 0.002 \cdot p_i$

- An absolute curved score: $AC_i(p) = 40 \cdot \sqrt{\dfrac{5,000 - p_i}{5,000}}$

- A relative linear score: $RL_i(p) = 75 - \dfrac{35}{\min\{p_1, p_2, p_3\}} \cdot p_i$

- A relative curved score: $RC_i(p) = 40 \cdot \dfrac{\min\{p_1, p_2, p_3\}}{p_i}$

The scores on quality range from 0 to 60 points. To simplify our example, we calculate the scores on quality with the absolute linear scoring method $AL_i(q) = 60 - 1 \cdot q_i$. This method leads to the quality scores 42, 45, and 47 for respectively suppliers 1, 2, and 3. The price scoring methods above lead to the price scores and total *WFS* scores (price scores + quality scores) as shown in Table 3. It is clear from the table that a different scoring method may lead to a different winner.

Supplier i	$AL_i(p)$	WFS_i	$AC_i(p)$	WFS_i	$RL_i(p)$	WFS_i	$RC_i(p)$	WFS_i
Supplier 1	31.6	73.6	16.0	**58.0**	40.0	82.0	40.0	82.0
Supplier 2	31.0	76.0	12.6	57.6	37.5	**82.5**	37.3	82.3
Supplier 3	30.5	**77.5**	8.9	55.9	35.4	82.4	35.4	**82.4**

Table 3: Price scores and total scores for the supplier selection example (winning total scores are indicated in bold)

This simple example leads to our main research question: *(how) can any supplier win by judiciously managing certain details – such as the gradient of a price scoring method – of the awarding mechanism?*

In our analysis in the next section, we make the following basic assumption.

Assumption 1. *We assume that there is no convex dominance.*

This assumption implies that no bid is dominated on all criteria by a convex combination of the other bids. Among other things, this also implies that no bid is the best bid on all criteria.

Results

In this section, we state several theorems and illustrate them using our supplier selection example. The proofs of the theorems can be found in the appendix of this paper. Our first theorem is a necessary theorem for the next theorems and is defined as follows.

Theorem 1. *In the WFS, weights do not play a role in the comparison of total scores.*

While the formal proof of this theorem is in the appendix, its validity is easily understood by recognizing that the weights on the criteria are always multiplied by the scores and consequently by the scale of the scoring methods.

Our second theorem builds on the first one. It defines and quantifies a problem that may arise when a buyer tries to identify an EMAT and has the intention of influencing the outcome of the tender. If the buyer does not publish certain scoring method information in an RfP, he can determine a scoring method – after receiving all the bids – such that the supplier of his choice wins the tender.

Theorem 2. *Under our assumption, we can make any supplier in a public tender win by a judicious choice of the gradient g_j of an absolute scoring method.*

In our example, Theorems 1 and 2 imply that if the buyer wants supplier 1 to score higher than supplier 2, he can do so by choosing the gradient of the price scoring method. Using our proofs, supplier 1 wins if $g_1 > g_2 \cdot \dfrac{q_1 - q_2}{p_2 - p_1}$ and $g_1 > 1 \cdot \dfrac{18 - 15}{4,500 - 4,200}$. So, for example, if $g_1 > 0.01$ in $AL_i(p) = 40 - g_1 \cdot p_i$ or in $AL_i(p) = 400 - g_1 \cdot p_i$, then supplier 1 has a higher total score than supplier 2.

While Theorem 2 applies to absolute scoring methods, we have a similar Theorem 3 that applies to relative scoring methods.

Theorem 3. *Under our assumptions, we can make any supplier in a public tender win by a judicious choice of the gradient g_j of a relative scoring method.*

In our example, Theorem 3 means for instance that if the buyers wants supplier 1 to score higher than supplier 2, he can do so by choosing the right gradient of the price scoring method such that $\dfrac{s_1}{\min\{p_1, p_2\}} > \dfrac{s_2}{\min\{q_1, q_2\}} \cdot \dfrac{q_1 - q_2}{p_2 - p_1}$ and $\dfrac{s_1}{4,200} > 1 \cdot \dfrac{18 - 15}{4,500 - 4,200}$. So, for example, if $g_1 > 42$ in $RL_i(p) = 40 - g_1 - \dfrac{g_1}{4,200} \cdot p_i$ or in $RL_i(p) = 400 - g_1 - \dfrac{g_1}{4,200} \cdot p_i$, then supplier 1 has a higher total score than supplier 2.

Practical implications

One obvious way to avoid the difficulty of having a buyer judiciously choosing the parameters of a scoring method to make his favorite supplier win is to publish these details in

advance in an RfP. This is an adequate measure in case of absolute scoring methods. However, in the case of relative scoring methods this is not adequate either as the suppliers have another possibility to influence the outcome of the supplier selection process: asking other suppliers (possibly in exchange for something else) to submit an additional bid. This is usually termed "bid rigging".

In our example, if the complete relative scoring method is published in the RfP, supplier 1 could use this knowledge to its advantage by inviting another supplier to submit a bid with a very low price even though that supplier may have dismal quality. This fourth supplier should submit a bid such that $\frac{35}{p_4} > 1 \cdot \frac{18-15}{4,500-4,200}$ that we rewrite as $\frac{35}{p_4} > 0.01$ and as $p_4 < 3,500$. Thus, if the price of supplier 4 is less than 3,500, supplier 1 wins the tender in stead of supplier 2. Note that this is just one disadvantage of using relative scoring methods. For more disadvantages of such methods, we refer to De Boer et al. (2006) and Albano et al. (2008).

The explanations of Theorems 1, 2, and 3 already show that there are disadvantages connected to not publishing all details of the awarding mechanism to suppliers. First, the buyer can influence which supplier wins. Second, when a relative scoring method is used, even the supplier can influence which supplier wins. But there is another and possibly even more important practical implication of these theorems:

It is optimal for the buyer to fully disclose all details of the awarding mechanism to suppliers.

It is not only buyers that face choices in the supplier selection process. The suppliers also face choices in preparing their bids. They must choose whether or not to work in overtime and deliver faster at a higher price or they can promise longer guarantee periods at a higher price et cetera. So, the suppliers have a bid selection problem before they hand in their bids. If the gradient of the scoring method is not published or if a relative scoring method is used, then the supplier does not know how many points he will score on the criteria. So actually, he does not know what the buyer prefers. The supplier will have to make an educated guess when selecting his bid.

If the buyer does publish all details, a rational supplier can and will use this knowledge to optimize his total score and this can only lead to bids that better fit the needs of the buyer (as they score higher). The supplier still has to deal with competition, but if the supplier can offer two different bids that make the same profit, he will submit the bid that leads to the highest total score.

Note that it is only possible to publish all details of the scoring method when an absolute scoring method is used. Relative scoring methods can be published as abstract formula, but a supplier can never calculate the scores as they depend on other bids coming in as well. Relative scoring methods will never guarantee to fit the preferences of the buyer, as their exact form and position depends on the bids coming in. As such, relative scoring methods replace the preferences of a buyer by a lottery, because the lowest price is determined by the market and not by the buyer. Only absolute scoring methods can be used to accurately represent the value functions of the buyer, as the buyer can indicate what he believes to be a good price and quality.

Limitations

Our assumption on the absence of convex dominance is rather mild as the presence of convex dominance basically implies that there is always a combination of other bids that dominates the dominated bid. This assumption is necessary to prove the theorems for the linear scoring functions. We do believe however that there will be non-linear scoring methods (both absolute and relative) that do not need this assumption to obtain the same results. We expect the general form of these methods to depend on the bids involved.

Our results apply to all supplier selection methods that use a weighted factor score. This means that besides the Weighted Factor Score method, our results also apply to common methods such as the Canadian method (De Boer et al., 2006), the Lowest Acceptable Price method (De Boer et al., 2006), and the Lowest Corrected Price method (Dreschler, 2009). All these methods can be used for multiple quantitative and/or qualitative criteria tenders. However, our results may not apply to other methods, such as Outranking or Value for Money.

Conclusions

We show that the Weighted Factor Score (WFS) supplier selection method is very sensitive to scoring methods. If certain parameters are not published in an RfP, an informed buyer can make almost any supplier win the tender by judiciously choosing some scoring method details. Therefore, it is wise to be completely transparent and publish full details of the scoring methods in the RfP. Not only does it prevent fraud, but we also prove that it yields better bids for the buying organization.

The EU directives do not explicitly state that tendering organizations should publish the scoring method used to calculate a score for a decision criterion. Based on our findings, we recommend adjusting the EU regulations to incorporate the requirement to publish all details of the scoring methods to be used.

Also, we prove that relative scoring methods are susceptible to some kind of influencing by supplier bidding strategies. Especially, it turns out that some commonly used scoring mechanisms may have detrimental effects on almost all methods in the sense that they might yield rank reversal. We provide mathematical proofs of the possibility of rank reversal.

A thorough understanding of the phenomena studied in this paper might prevent the problems observed from occurring. The insights gained through this analysis may help (public) procurement practitioners select the right supplier selection method and apply them in such a way that the supplier selection method itself does not lead to problems and discussions.

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Appendix

We define:
- α as the vector containing the price and delivery time of the winning bid;
- A as the vector containing the total score of the winning bid;
- β as the vector containing the prices and delivery times of the other bids;
- B as the vector containing the total scores of the other bids.

Assumption 1. $\beta \cdot \lambda < \alpha$ and $\lambda \cdot e = 1$ for each λ.

Proof of Theorem 1. If we assume there are two criteria (i.e., price and quality) that are scored with an absolute linear scoring method, then the total score for each supplier i is $WFS_i = w_1 - g_1 \cdot p_i + w_2 - g_2 \cdot q_i$. As our question is to find out whether and when each supplier in a public tender can win, we need to compare the total scores of all suppliers to each other. If there are two suppliers and we want the first supplier to win, then $WFS_1 > WFS_2$. We can rewrite this as $w_1 - g_1 \cdot p_1 + w_2 - g_2 \cdot q_1 > w_1 - g_1 \cdot p_2 + w_2 - g_2 \cdot q_2$, as $-g_1 \cdot p_1 - g_2 \cdot q_1 > -g_1 \cdot p_2 - g_2 \cdot q_2$, as $g_1 \cdot (p_2 - p_1) > g_2 \cdot (q_1 - q_2)$, and as $g_1 > g_2 \cdot \dfrac{q_1 - q_2}{p_2 - p_1}$. A similar line of reasoning can be applied to tenders with three or more criteria and/or three or more suppliers, because in all cases, the weights cancel each other out. Thus, the weights of the criteria do not play a role. □

Proof of Theorem 2. We prove Theorem 2 using a proof by contradiction. As absolute linear scoring methods are a subset of absolute curved scoring methods, we prove by contradiction that Theorem 2 is correct for absolute linear scoring methods. By doing so, we also prove by contradiction that the theorem is correct for absolute curved scoring methods. We start our proof as follows. As weights are irrelevant, we assume them being 0 and leave them out of

our equations. Given our definitions for A and B we have $g \cdot \beta = B$ and $g \cdot \alpha = A$. Now, α does not win if there is an λ for which $B \cdot \lambda \geq A$. We can rewrite this as $(g \cdot \beta) \cdot \lambda \geq g \cdot \alpha$ and as $\beta \cdot \lambda \geq \alpha$. This is in contradiction with Assumption 1 that states that $\beta \cdot \lambda < \alpha$ and $\lambda \cdot e = 1$ for each λ. $\square$

Proof of Theorem 3. Similar to an absolute linear scoring method, a relative linear scoring method is of the form $a - b \cdot p_i$. Following a similar line of reasoning as in the proof of Theorem 1, the variable a does not play a role. After all, using s as the slope of the method, we can write

$$w_1 - s_1 - \frac{s_1}{\min\{p_1, p_2\}} \cdot p_1 + w_2 - s_2 - \frac{s_2}{\min\{q_1, q_2\}} \cdot q_1 > w_1 - s_1 - \frac{s_1}{\min\{p_1, p_2\}} \cdot p_2 + w_2 - s_2 - \frac{s_2}{\min\{q_1, q_2\}} \cdot q_2$$

and rewrite this as $-\dfrac{s_1}{\min\{p_1, p_2\}} \cdot p_1 - \dfrac{s_2}{\min\{q_1, q_2\}} \cdot q_1 > -\dfrac{s_1}{\min\{p_1, p_2\}} \cdot p_2 - \dfrac{s_2}{\min\{q_1, q_2\}} \cdot q_2$.

We can rewrite this as $\dfrac{s_1}{\min\{p_1, p_2\}} \cdot (p_2 - p_1) > \dfrac{s_2}{\min\{q_1, q_2\}} \cdot (q_1 - q_2)$, as

$\dfrac{s_1}{\min\{p_1, p_2\}} > \dfrac{s_2}{\min\{q_1, q_2\}} \cdot \dfrac{q_1 - q_2}{p_2 - p_1}$, and as $g_1 > g_2 \cdot \dfrac{q_1 - q_2}{p_2 - p_1}$. Now, we can use the same proof as we used for Theorem 2 to prove Theorem 3. $\square$