Selecting an award mechanism

A support system for buyers

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Management summary

Motivation
There has been an increasing interest for e-tendering in the last couple of years, where the ultimate goal for a buyer is to obtain an optimal combination of high quality and low prices. Therefore, it is important to choose the right bid when buyers evaluate a tender. To do this, an award mechanism will be used, which ranks different bids based on quality and/or price. Buyers have the freedom to choose the award mechanism of their preference, which is a crucial element of the tender, since it determines which supplier will be contracted. However, there is little support available in order to make that choice. So buyers face different award mechanisms which consist of several parameters and they do not (all) know the impact of those parameters and how to use the different award mechanisms. Therefore, this research provides support on how to make a well-considered choice between the different award mechanisms from the buyer's perspective.

This research has been executed on behalf of Negometrix, a company that owns a private e-procurement platform on which contracting authorities can publish announcements and tenders. Although this report is characteristic for Negometrix and only focuses on the award mechanisms processed within their platform, it may also be used by other organizations that need to choose between different award mechanisms.

Research goal
The aim of this essay is to get an overview of the evaluation phase from the buyer's perspective and to give recommendations on how buyers may be supported best in making their decision of choosing an award mechanism. To do this, it is important to get an in-depth understanding about the different award mechanisms, map the current situation and involve buyers to check their preferences. All activities undertaken within this research will contribute to answering the research question:

How to support buyers of Negometrix in making their decision between different award mechanisms implemented in the platform?

Method
There are three approaches that will be used in order to get to a solution to the research question. The first approach is conducting a literature review to get an in-depth understanding on the different award mechanisms. The second approach is doing face-to-face in-depth interviews with buyers, to check if they regard the developed support as useful and what requirements they face when developing support. The last method is related to analysis of the current situation, to see how buyers are supported nowadays and how they are dealing with the decision between different award mechanisms. The research method may be summarized as shown in Figure 1.

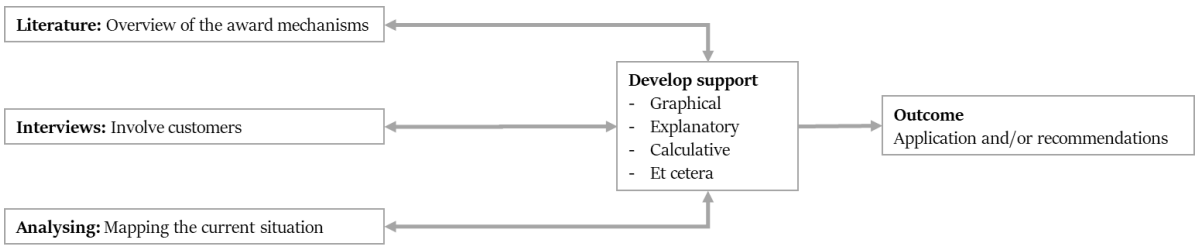

***Figure 1**: Summary of the problem solving approach*

Results
Negometrix has implemented seven award mechanisms in its system: NX Utility Index, Weighted Factor Method, Value Based Awarding, Low Bid Scoring Formula, log formula, value for money 50/50 index and rank on scores in survey.

Information about the different award mechanisms can be found in *2. The different award mechanisms: A literature review*. The similarities and differences between the different award mechanisms are mentioned in *3. An overview of the differences between the different award mechanisms.*

After some research has been conducted about the different award mechanisms, the current situation had been analysed, starting with some explanations on the available support for buyers in making their decision between the different award mechanisms nowadays. This is followed by the parameters that need to be defined by buyers beforehand (after choosing one award mechanism). Those aspects can be found in *4.1 How are buyers supported in choosing an award mechanism nowadays?*

The next step in analysing the current situation is to determine how the award mechanisms are used. Worldwide, the Low Bid Scoring Formula is the most used award mechanism, however, within the Negometrix platform, buyers prefer to use the NX Utility Index. This may result from the fact that the formula is considered to be relevant by Negometrix itself and is recommended to its buyers. The ratios on how the award mechanisms are used within the platform can be found in *4.2 How are the award mechanisms used in the current situation?*

Thirdly, complaints have been analysed in order to check whether buyers face difficulties in choosing an award mechanism or not. Remarkably, only 4% of all calls are linked to buyers asking for support on award mechanisms. This analysis can be found in *4.3 Are buyers complaining about the award mechanisms?*

Now that the current situation is analysed and the different award mechanisms are clear, buyers will be involved into the process. Five in-depth interviews have been conducted that took place face-to-face. Participants were buyers varying from a hospital to a bank. The interviews show that some buyers have questions in choosing an award mechanism, but want to avoid it by copying a near buyer or only use one formula where they are familiar with. They want to get familiar with other formulas as well, as long as it does not take a lot of time. The formulas they are using nowadays differ per buyer, all with their own reasoning. Additionally, they do see added value in the development of support and prefer a graphical way of showing the support. However, buyers also think that it would be even better if there would be a combination of graphical support, calculations and explanations. The outcomes of the interviews can be found in *4.4 How do buyers react to the existing platform and the corresponding award mechanisms?*

Lastly, some research has been done in order to find characteristics of a decision support system and to check if there is information available on how to choose a certain award mechanism. Outcomes of this research can be found in *5. Characteristics to develop a decision support system.*

Conclusion and recommendations

First of all, buyers need to be aware of the influence of their choice which is done by comparing all award mechanisms based on their ranking, which can be found in *Appendix V: Another award mechanism may change the ranking*.

Additionally, three different kinds of support have been developed to support buyers in making their decision between the different award mechanisms implemented in the platform. All support can be found in *6. Development of a support system (SS)*. The support contains decision trees, a preference curve and a simulation model.

The best way to support buyers is to use one of the developed support models or combine the different kinds of support in order to choose an award mechanism.

It is recommended to process the given support in this thesis into the system of Negometrix. Additionally, some recommendations on how to improve future research will be given:

- Implement other award mechanisms to make the support usable by all buyers worldwide
- Additional support may be implemented, focusing on how to determine the parameters.
- Conduct additional interviews, to get a broader range of buyers and more insight.
- Do additional research to check the advantages as well as disadvantages of the existing support system.

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1. Introduction

There has been an increasing interest for e-tendering in the last couple of years. E-notification has already been mandatory for all contracting authorities since 2013, but the European Law requires all procedures and tenders to be electronical by October 2018. In the Netherlands, this obligation is already in effect since July 1, 2017. Each Dutch contracting authority is responsible for the management of its own public procurement procedure, regardless of its level of authority (European commission, 2016).

Negometrix is a company owning a private e-procurement platform on which contracting authorities can publish announcements and tenders. Buyers can compose a tender and suppliers can provide bids through that platform. Therefore, Negometrix helps contracting authorities with their responsibility for the management of their own public procurement procedure.

In the procurement process, it is important for buyers to choose the right bid when they evaluate a tender. This choice will be made based on the outcome of an award mechanism. Award mechanisms rank different bids based on quality and/or price. The mechanism is straight forward in case it is on price only, it becomes more complex in case the mechanism includes price and quality. In the EU, there is a preference for award mechanisms that combine price and quality into a total score (Verdeaux, 2003). Currently, seven award mechanisms have been implemented in the Negometrix platform.

1.1 Problem description

For the buyer, the ultimate goal of public procurement is to obtain an optimal combination of high quality and low prices. Achieving this objective requires competitive bidding, low transaction costs and an absence of corruption and favouritism (Bergman and Lundberg, 2013). Buyers do have the freedom to choose an award mechanism in order to reach that goal. This choice is a crucial element of the tender because it can influence which supplier will be contracted. As a result, buyers face different award mechanisms which consist of several parameters and they do not (all) know the impact of those parameters and how to use the different award mechanisms. So Negometrix supports buyers in their choice of award mechanism by providing an Excel file that allows buyers to compare the effect of applying different formulas on different bids. In addition, the most commonly used formulas are step-by-step explained in separate documents that buyers can add as attachments to tender procedures. However, more support could be provided ensuring all award mechanisms are fully covered and make it understandable for any buyer.

To solve this problem, this thesis will give an overview of the evaluation phase from the buyer's perspective and will provide a recommendation on how buyers may be supported best in making their decision of choosing an award mechanism.

1.2 Relevance of the assignment

It is obliged to have the economical most advantageous tender (EMAT) or choose the lowest price in certain well-underpinned cases when evaluating a tender (Public Procurement Act, 2013). This should be achieved by taking both quality and price into account, which can be done with several award mechanisms. So it is important to be aware of the different award mechanisms available to reach the EMAT and have a look at the elements that influence the outcomes of those award mechanisms.

Buyers are often not too well informed on the different award mechanisms available and they may not be aware of the influence of their choice. Therefore, this research aims to contribute to the understanding of different award mechanisms, their underlying characteristics and it can offer direct help to Negometrix, because it will also improve their capacity to support buyers to understand the award mechanisms. This understanding is important, since buyers need to be transparent in their choice for an award mechanism (Mateus, Ferreira & Carreira, 2010), therefore, it is of relevance that they are able to underpin their decision.

In order to make that decision, it is important to understand the differences between the different award mechanisms. Especially since outcomes of the different award mechanisms sometimes differ from each other. For example, in some cases it could be that when a buyer uses methodology X, supplier 1 will win the tender. However, when the buyer uses methodology Y for the same data may cause supplier 2 to win the tender. There is a need to get an in-depth understanding of the different award mechanisms available and why they differ from each other.

All award mechanisms contain different parameters. Those parameters ensure that requirements and wishes of buyers are expressed in the formulas of an award mechanism. However, an in-depth analysis of the different parameters does not fall within the scope of this research. On the other hand, buyers do need to know how they can express themselves and which formula represents their desires best. Therefore, the parameters will only be mentioned shortly. So this research will give buyers insight on how to use a certain method and to what extent they are able to implement their desires into an award mechanism.

It can be concluded that this essay is of relevance because of the importance of understanding the different award mechanisms and the development of support for helping buyers to make their decision between different award mechanisms.

1.3 Research questions

As already mentioned the aim of this essay is to get an overview of the evaluation phase from the buyer's perspective and give recommendations on how buyers may be supported best in making their decision of choosing an award mechanism.

To maintain clarity and be able to fulfil the assignment within the intended time frame, there is chosen to focus on the award mechanisms already implemented in the Negometrix platform.

In order to develop support for buyers in making their decision between different award mechanisms it is essential to get insight in the different award mechanisms and to determine how they differentiate from each other. This requires a literature review. This literature review should answer knowledge questions, such as:

- How do the different award mechanisms work?
- What are the characteristics of a specific award mechanism?
- What are the differences between the different award mechanisms?
    - In a graphical way
    - With an explanation
    - With a calculation

As background, it is also important to get the answer to some questions to map the current process within Negometrix.

- In what way is there already support available for buyers in making their choice of award mechanism?
- Which parameters need to be defined by buyers when choosing a certain award mechanism?
- How many times are the different award mechanisms used (in relation to each other)?
- Are there a lot of complaints or questions in the service desk about award mechanisms?

Besides mapping the different award mechanisms and analysing the current situation, there are also some knowledge questions which are linked to customers of Negometrix, specifically the buyers, these questions are:

- Are buyers facing difficulties in choosing an award mechanism? Do they fully understand it?
- What award mechanism do buyers normally use? And why?

- In what way do customers like to see the differences between the different award mechanisms? (Graphical, explanatory or with calculations)
- What kind of support are customers looking for in choosing between different award mechanisms?

Answering all these questions will contribute to answering the overall research question: *How to support buyers of Negometrix in making their decision between different award mechanisms implemented in the platform?*

1.4 Problem solving approach

Executing the project is based on answering all (sub)questions. The different (sub)questions require different problem solving approaches.

The first group of questions is linked to getting an in-depth understanding of the different award mechanisms. The best way to answer those questions is to conduct a literature review. There is already some information available on the site of Negometrix about the different award mechanisms. However, it is not enough to fully understand the mechanisms. Therefore, the literature review should provide some answers on what are specific characteristics for a certain award mechanism and how do those characteristics differentiate from each other. So the aim of the literature review will be to acquire a full understanding of the different award mechanisms that are implemented in the Negometrix platform.

The second group of questions is linked to the customers. The best way to get answers to those questions is to get in contact with customers. In-depth interviews with customers will be conducted to gain answers to (sub)questions and to get an idea of the different kinds of customers at Negometrix.

The third and last group of questions will give an insight on the current situation. Answers to those questions will be gained by analysing data from Negometrix.

With the answers to all sub-questions a support system will be developed. So that will be the final step towards answering the research question. This problem solving approach can be summarized as shown in Figure 1 and Figure 2.

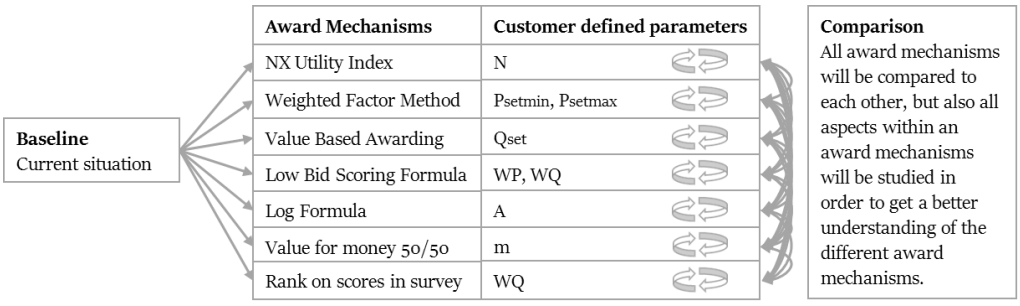


Figure 2: *How the different award mechanisms will be handled during the research*

2. The different award mechanisms: A literature review

First of all, every award mechanism will be described based on information already available at Negometrix and will be shown graphically. Thereafter, there will be more in-depth research on the different award mechanisms and their characteristics. All this information will be brought together to explain the different award mechanisms. In order to avoid repetitions all abbreviations will be explained only one time. Additionally, graphs to show the differences when changing the parameters will be shown in *Appendix I: What happens when changing the parameters?*

2.1 NX Utility Index

The formula of the NX Utility Index (u) used by Negometrix can be formulated as:

$$u = \left[\frac{(1-((Q_{best}-Q_i)*N))}{P_i}\right] * P_{best} \qquad (1)$$

Q_{best} = Bid with best quality (the higher the better) with a maximum of hundred percent.
Q_i = Quality for bid *i*
N = $Weight_{quality}$ / $Weight_{price}$
P_i = Price for bid *i*
P_{best} = Bid with best price (the lowest price bid by any supplier).

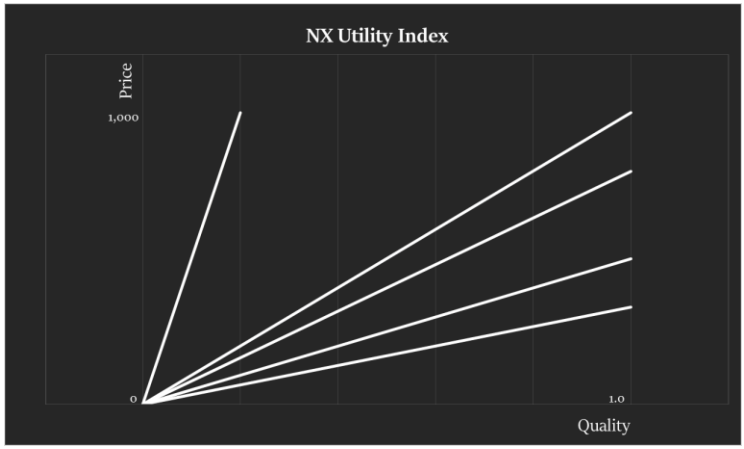


***Figure 3**: An example of a graphical representation of the NX Utility Index*[1]

The outcomes of the formula are linear lines. Although it seems that every line crosses the origin, this does not hold for all outcomes of the formula. Additionally, it should be noted that the slope of the lines depends on the chosen *N* (the higher the *N*, the steeper the line). However, *N* will not be chosen directly but is a derivative of *WP* and *WQ*.

The bid with the highest utility index will be ranked first and will be chosen. For every supplier, it will be calculated what price should have been set in order to be equal to the bed bid with the highest index. This price is also known as the Best Buy price and can be calculated with:

$P_i - (u / u_{best} * P_i)$ (2)

Where u_{best} is the utility index of the bid that is ranked first.

[1] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. For this specific example, N was equal to 1. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism.

The NX Utility Index is originated in a best practice in Italy and adopted by Negometrix. It is based on one other formula, namely value for money (which will be explained in *2.6 Value for money 50/50 index)*. This is demonstrated best by comparing the formulas, which will be done in *3.2.1 Comparison between NX UI and VFM*.

Finally, some characteristics of the formula will be mentioned, based on information available at Negometrix:
- UI may become negative by using a high weight for Quality (*WQ* > 50%)
- All offers on the same line have the same score in an equal Quality/Price-ratio
- The weight for price (*WP*) should be higher than zero (otherwise, no formula is needed; the price will be irrelevant and the bid with the highest quality will win the tender).
- The best buy is equal to the price discrepancy, it is possible to rank offers based on their best buy
- An offer that scores 100% on the NX UI does have the best quality as well as the best price.

Negometrix has added the parameter *N* to create the possibility to buyers to give weights to both price and quality themselves. Additionally, P_{best} is added to the formula in order to ensure the maximum score of the NX Utility Index is hundred percent and to avoid the score to be a really small number as price can be thousands or millions. However, multiplying *N* only with ($Q_{best} - Q_i$) does not ensure that the outcomes will be positive. Therefore, there is an option to change the formula into Equation (3).

$$u = \left[\frac{(1-(Q_{best}-Q_i))}{P_i} * N\right] * P_{best} \quad (3)$$

In that case, the outcomes will never be negative. Additionally, P_{best} does not ensure the maximum outcome is equal to hundred percent anymore, therefore it does not really add something to the formula. Thus, it is possible to change P_{best} into a multiplier that is based on the potential price range to get outcomes with realistic numbers. This results in Equation (4).

$$u = \left[\frac{(1-(Q_{best}-Q_i))}{P_i} * N\right] * m = \left[\frac{(1-(Q_{best}-Q_i))}{P_i} * \frac{WQ}{WP}\right] * m = \left[\frac{WQ*(1-(Q_{best}-Q_i))}{WP*P_i}\right] * m. \quad (4)$$

As one can see, this is an extended version of the value for money method, including weights to the formula. Nevertheless, application of the formula shows that it does not give clear rankings. Changing the weights of both price and quality in this formula will not have any influence on the ranking. Therefore, the formula cannot be used in practice.

2.2 Weighted Factor Method

The formula of the Weighted Factor Method (WFM) used by Negometrix can be formulated as:

$$WFM = WQ * Q_i + WP * ((P_{setmax} - P_i)/(P_{setmax} - P_{setmin}) \quad (5)$$

WQ = Weight Quality
WP = Weight Price
P_{setmax} = Is the maximum price of the range where all bids must be in between.
P_{setmin} = Is the minimum price of the range where all bids must be in between.

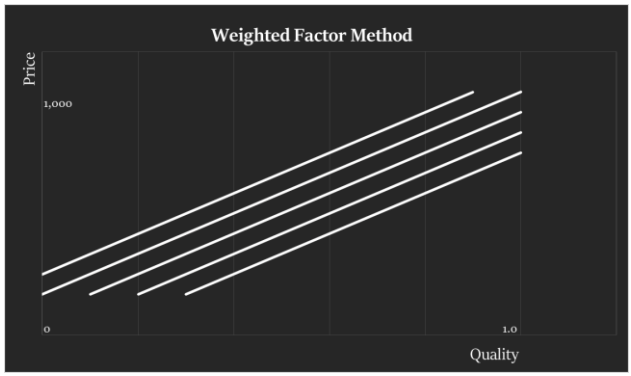


***Figure 4**: An example of a graphical representation of the Weighted Factor Method*[2]

The outcomes of the formula are linear lines, which lie parallel to each other. The steepness of the lines depend on the determined parameters. All parameters influence the steepness of the lines individually[3].

The bid with the highest score will be ranked first and will be chosen. The best buy price in this case can be calculated with Equation (6).

$$P_i - (WFM_{best} - WFM) * ((p_{setmax} - p_{setmin})/WP)) \quad (6)$$

Where WFM_{best} is the Weighted Factor Method of the bid that is ranked first.

It seems there is a fixed formula to use the Weighted Factor Method, however this is not the case. The award mechanism is equal to assigning each bid an overall score as weighted sum of different scores on all criteria involved. To get to that score, WFM requires defining scoring functions for every criterion and the determinations of weights per criterion to determine the overall scores. The scoring rule used may be defined in many different ways (Telgen and Schotanus, 2010).

According to Telgen and Schotanus (2010), there are four different ways to determine a score:

- Using an absolute linear score
- Using an absolute curved score
- Using a relative linear score
- Using a relative curved score

One possible way to calculate an absolute linear score, an absolute curved score, a relative linear score and a relative curved score are shown below in respectively Equation (7), Equation (8), Equation (9) and Equation (10).

$$Pscore = Pscore_{max} - (value < P_{max} / Pscore_{max}) * P_i \quad (7)$$

$$Pscore = Pscore_{max} * \sqrt{\frac{ScoreaboveP_{max} - P_i}{ScoreaboveP_{max}}} \quad (8)$$

$$Pscore = m - \frac{n}{P_{best}} * P_i, \text{ where m - n is equal to } Pscore_{max} \quad (9)$$

$$Pscore = Pscore_{max} * \frac{P_{best}}{P_i} \quad (10)$$

[2] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. For this specific example, P_{setmin} was equal to zero and P_{setmax} was equal to 1000. Both WP and WQ were equal to 50%. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism.

[3] See *Appendix I: What happens when changing the parameters?*

Looking at the formula used by Negometrix, $((P_{setmax} - P_i)/(P_{setmax} - P_{setmin})$, it becomes evident that an linear absolute scoring rule is used. This is explicable by the fact that it does not depend on other bids, since it does not involve the best price / quality or an average of it.

The use of this formula imposes the buyer to set P_{setmax} and P_{setmin}. Moreover, the choice of P_{setmax} and P_{setmin} highly determines the ranking of the bids. Choosing a wide range decreases the influence of the price of a bid. This effect obviously interplays with the weight of price.

There are also some characteristics that should be taken into account while considering the WFM (Telgen and Schotanus, 2010):

- 〉 There should be no convex dominance, no bid is dominated on all criteria by a convex combination of all other bids (no bid is the best bid on all criteria).
- 〉 Weights do not play a role in comparison to total scores, weights cancel each other out.

2.3 Value Based Awarding

The formula of the Value Based Awarding, also called the evaluation value (VBA) used by Negometrix can be formulated as:

$$VBA = P_i - (Q_{set} * Q_i) \quad (11)$$

Value discount = Q_{set} * Q_i
Q_{set} = This is a discount that will be given to the price when a certain level of quality is met. The buyer gives weights to the different forms of quality in the form of a monetary amount. That weight will be discounted equivalent to the amount of quality that is offered.

Q_{set} can be determined directly if there is a direct relationship between the quality offered and the value it determines. Another approach would be to refer back to the budget allocated for that specific tender. It should be noted that Q_{set} is not the cost that suppliers incur in order to deliver the quality offered, but it is a value that the buyer attributes to a bid (Sciancalepore and Telgen, 2011).

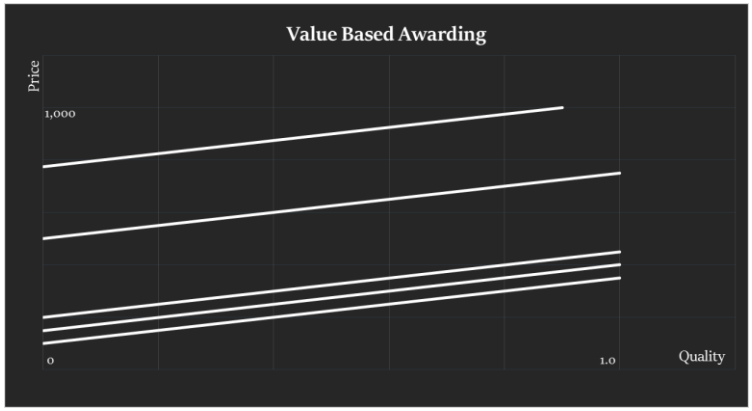


***Figure 5**: An example of a graphical representation of Value Based Awarding*[4]

The outcomes of the formula generate linear lines, which lie parallel to each other. The steepness of the lines depends on the determined parameter.

[4] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. For this specific example, Q_{set} was equal to 250. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism.

The bid with the lowest VBA score will be ranked first and will be chosen. The best buy price in this case can be calculated with Equation (12).

$$P_i - (VBA - VBA_{best}) \quad (12)$$

Where VBA_{best} is the lowest evaluation value derived from the bid that is ranked first.

According to Sciancalepore and Telgen (2011), VBA is a price correction mechanism for bid evaluation in a EMAT perspective. The approach has a number of advantages as well as disadvantages:

+ It allows aggregation and comparison of data with different units. It provides real costs of each bid; the decision maker can get an idea of how much every bid actually costs, which is understandable by anyone
+ It only needs the definition of Q_{set} and the scaling of bid quality, so there are no weights or price scoring functions required.
+ It respects important requirements of fairness and transparency; all bidders are evaluated in the same way.
- It considers an unique quality indicator (can easily be overcome by using a multidimensional formulation.
- The implementation of the model requires the determination of Q_{set}. This is a subjective choice and may leave room for a discretionary choice aiming at favouring one bidder to the detriment of the other ones.

To avoid the last disadvantage, the task of determining Q_{set} may be assigned to a committee with adequate participation of all evaluators and the determination and communication of Q_{set} should be done before suppliers are able to submit their offers.

The graph shown in this section look similar to the graph of the Weighted Factor Method. Therefore, comparisons between the methods will be made in *3. An overview of the differences between the different award mechanisms*.

2.4 Low Bid Scoring Formula

The formula of the Low Bid Scoring Formula (score) used by Negometrix can be formulated as:

$$Score = WP * \frac{P_{best}}{P_i} + WQ * Q_i \quad (13)$$

Note that this formula is equal to one formula already mentioned under the Weighted Factor Method award mechanism (using a relative curved score). This formula shows the summation of a score of quality and a score of price. Therefore, the method can be regarded similar to the WFM, only using different scoring rules. In order to check this, the formulas will be compared in *3. An overview of the differences between the different award mechanisms*.

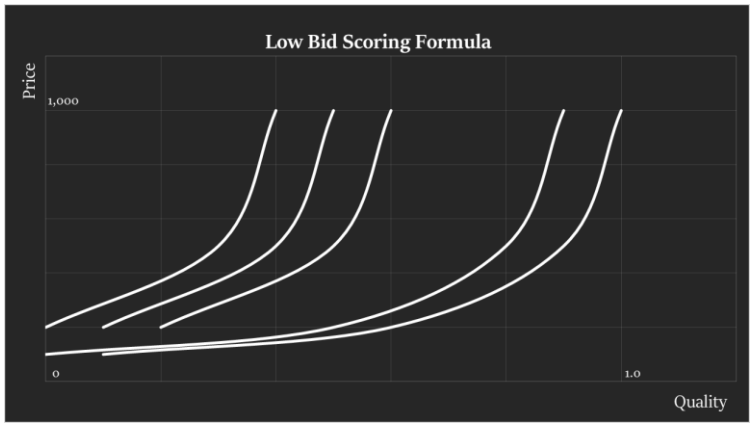


***Figure 6**: An example of a graphical representation of the Low Bid Scoring Formula*[5]

The outcomes of the formula generate curved lines.

The bid with the highest score will be ranked first and will be chosen. The best buy price in this case can be calculated with Equation (14).

$$P_{best} * WP / (Score_{best} - WQ * Q_i) \quad (14)$$

Where WFM_{best} is the Weighted Factor Method of the bid that is ranked first.

The Low Bid Scoring Formula may be divided into two parts: a relative part and an absolute part. The relative part is equal to the lowest scoring rule, $WP * \frac{P_{best}}{P_i}$, where the cheapest bid always gets the best score. With this formula holds the lower P_{best}, the steeper the line. (Albano, 2014).

This relative scoring rule for price is the most used formula in the world (Chen, 2008). One disadvantage of this formula is that it allows the ranking to change when one important offer is deleted. However, the advantage of this formula is that it requires less parameters to define. It is only possible to recalculate the ranking when it is mentioned upfront, which may be hard to prove. When the price is judged relatively on several criteria, it is possible that the current supplier has advantages in comparison to other suppliers. This originates from the fact that the current supplier knows what is expected from the purchaser and the expected amount that will be asked. This knowledge is essential in the calculation to make the most optimal mix of prices. (Chen, 2009). However, one study from Merckel (2015) shows that the use of a relative formula is in some cases not fully defendable and the times that the ranking change due to the use of the relative formula is minimal. However, it is proven that rank reversal may occur.

Experiences from Negometrix show that the Low Bid Scoring Formula is used by almost all foreign buyers. This may result from the legislation of Italy, where it is advised by law to use the formula (Codice Appalti / Decrecto 207 2010 GURI). Additionally, the formula is part of the standard procurement procedure from the World Bank and is applied in Federal US supported procedures such as tender for the Government of Honduras "e-GP Information System for HonduCompras CB-UMBRAL-01-2017" published in June 2017. Also the EBRD uses the formula in their procedures. This shows that the formula is considered to be relevant and adopted abroad. (Negometrix, 2017).

[5] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. For this specific example, WP and WQ were both equal to 50%. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism.

2.5 Log formula

The log formula (score) used by Negometrix can be formulated as:

$$Score = WQ * Q_i + WP \left(1 - \frac{\log\left(\frac{P_i}{P_{best}}\right)}{\log(A)}\right) \quad (15)$$

A = a value that should be determined by the buyer beforehand. The value determines the number of times the lowest price gets zero points.
For example, when *A* is equal to two, a bid that is twice as expensive as a bid with the lowest price will receive zero points for its price. In practice, *A* is often equal to 1.5, 2 or 3. Remark: When a bid is >*A* as expensive as the lowest price, the price points will be negative. The bid with the lowest price will get all price points, irrespectively of the value of *A*. This results from the equality of P_i to P_{best} in that case and the fact that log(1) is equal to zero. *A* should be greater than one.

In the formula, it would be wise for the contracting authority to define a lower bound and an upper bound for quality. If not, a supplier might offer an unrealistic value (Chen, 2008).

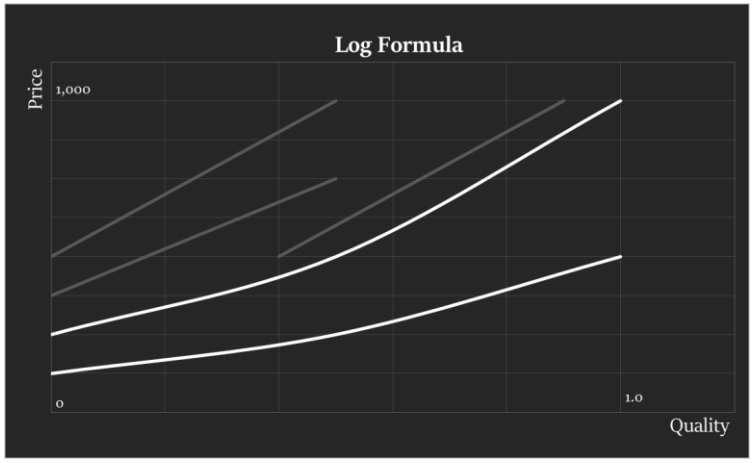


***Figure 7**: An example of a graphical representation of the log Formula*[6]

The outcomes of the formula generate curved lines. The form of the lines is mainly depending on the determination of *A*.

If the appearance of the graph proves to be straight lines, this represents equal return for the contracting authority. However, for the buyer, the law of diminishing marginal return means that the dissimilar curves will not be straight lines – every additional euro spent on improving availability has a diminishing effect (Chen, 2008).

The bid with the highest score will be ranked first and will be chosen. The best buy price in this case can be calculated with Equation (16).

$$10^{(score_{best} - WQ * Q_i - WP) * \log(A) / (-WP) + \log(P_{best})} \quad (16)$$

[6] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. For this specific example, WP and WQ were both equal to 50% and A was equal to 4. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism. However, there was not enough data available to generate 5 lines (the grey lines are not finished yet).

Where $score_{best}$ is the highest score derived from the bid that is ranked first.

The formula is devised by Chen (2005) in order to avoid ranking reversal. Ranking reversal arises when after adding or removing one or more bids, rankings of individual bids are different than before. A price related ranking reversal will be defined as a ranking reversal caused by change of the highest, lowest or e.g. average price of all submitted bids. A quality related ranking reversal will be defined as a ranking reversal caused by a change of e.g. the highest quality of all submitted bids (Stilger, 2011).

The log formula makes the ranking reversal impossible, because the difference between the scores of two tenders only depend on the ratio between two prices and is not affected by a third ratio, which may be the best score and declared invalid (Chen, 2008). So one could say: As a result of the logarithmic scale, P_{score} of different bids do not depend on P_{best}. When P_{best} changes, the mutual rankings of all other bids will remain.

Ranking reversal is part of the social choice theory, an econometric theory which analyses choice rules, i.e., rules by which the best option is selected from a number of alternatives, based on the individual preferences of a group of people. According to that social choice theory, an award mechanism should have the following five properties (Chen, 2008):

1. *Unanimity*: if each criterion determines that supplier A offers a better bid than supplier B, then in the final ranking supplier B may not be preferred to supplier A.
2. *Non-dictatorship*: There should be no criteria involved that determines the final ranking on its own under all circumstances.
3. *Universal Domain*: For each group of suppliers and thus for all possible rankings determined by the criteria, the award system must determine a winner (or a set of winners).
4. *Independence of Irrelevant Alternatives*: A relative ranking between two alternatives should not depend on a third alternative in the final ranking.
5. *No egalitarism*: The award system may not be trivial, i.e. it should not always be the case that all suppliers have the same ranking.

If there are more than two tenders, there is no award mechanism based on ranking alone possesses all five properties. This is why these properties seem to be natural and rather minimal requirements that an award mechanism should fulfill.

Again, the formula sums up a score of quality and a score of price. Therefore, the method falls under the WFM, only using a different scoring rule. In order to verify this, the formulas will be compared in *3. An overview of the differences between the different award mechanisms*.

2.6 Value for money 50/50 index

The formula of the value for money 50/50 index (VFM) used by Negometrix can be formulated as:

$$VFM = (Q_i / P_i) * m \quad (17)$$

m = a multiplier, which is used in the Negometrix platform. It is not part of the official formulation, but is used to avoid relatively small numbers which make it difficult to differentiate the bids from each other.

The quality score can be an overall estimation of the bid or can determined as the weighted sum of a set of scores on various qualitative factors. Additionally, the 50/50 stands for an equal distribution between price and quality.

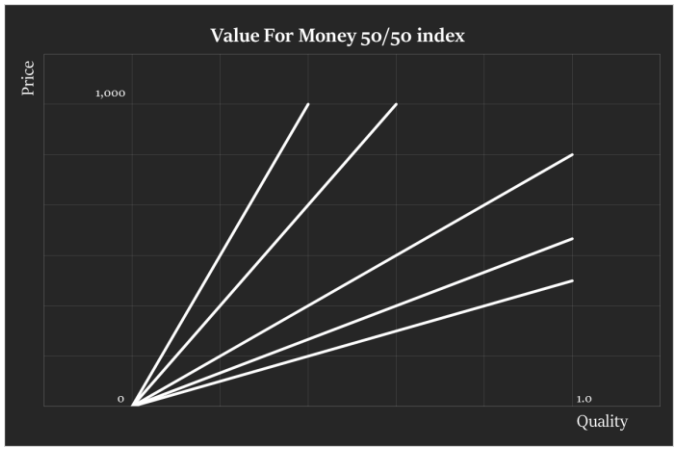


***Figure 8**: An example of a graphical representation of the value for money 50/50 index*[7]

The outcomes of the formula generate linear lines that all pass the origin.

With this formula, quality will be determined based on several criteria, which are awarded with points. The supplier with the highest score will win the bid. The best buy price in this case can be calculated with:

$$Qi / VFM_{best} \quad (18)$$

Where VFM_{best} is the highest score derived from the bid that is ranked first.

The price-quality ratio or VFM formula (S = P/Q) is exactly following the requirements of the Directive: determine the best price/quality. Who is willing to deliver the most quality for your money? The formula is suitable in several situations. The expected scatter of scoring for quality is essential for the weight of quality (e.g. 10-40: pays 300% extra, 80-100: pays 25% extra). Also S = Q/P could be used, in that case the bid with the highest outcome will win the bid. In this case, p = zero should be avoided. (PIANOo, 2016)

As already mentioned, the NX Utility Index can be considered as a derivative of the value for money method. To show the similarities, the formulas will be compared in *3. An overview of the differences between the different award mechanisms.*

2.7 Rank on scores in survey

The rank on scores in survey is the last implemented option for an award mechanism. It allows buyers to create their own formula by creating their own price evaluation method. Therefore, it is not really a profound method since there are no specific P/Q calculations involved. The bid with the highest score will win the tender. To determine the score, it is possible to score both award criteria and price in a survey and rank based on those scores. This method is useful to describe the wishes of a buyer, however it does not really depend on a certain theory and can therefore not be underpinned.

[7] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism.

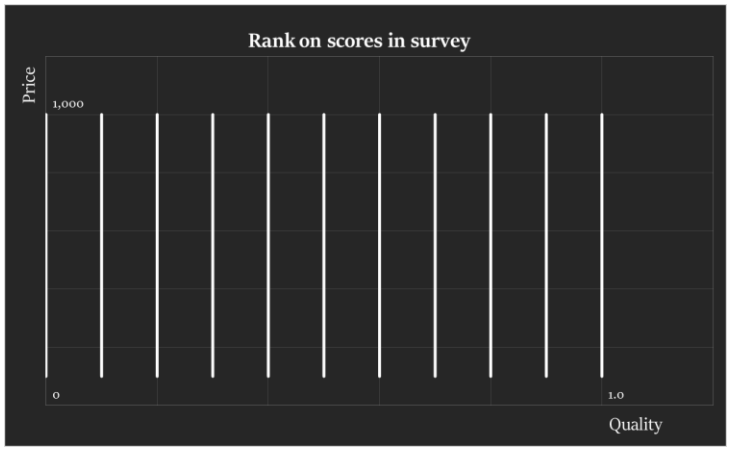


***Figure 9**: An example of a graphical representation of the rank on scores in survey*[8]

The outcomes are equal to the amount of quality, which concludes that per quality-level only the price differentiates. Therefore, all lines are straight and vertical.

The rank on scores in survey looks similar to the budget method: the price will be set before the tender opens. Subsequently, the ranking will be based on quality only. Below a pro and con will be mentioned (PIANOo, 2016):

+ A buyer does not pay more than its available budget.
- Under these circumstances, there is a lot of additional quality requirements that will not be met.

[8] This graphic is based on calculations within a price range of [0;1000] and a quality range of [0;1]. Some of the outcomes have been processed into lines in order to give an idea of the award mechanism.

3. An overview of the differences between the different award mechanisms

All award mechanisms follow different paths to follow to get to the best offer. An overview of the paths on how to get a better score for suppliers can be found in *Appendix II: How to get to the best score?* This chapter will focus on the similarities and differences between the award mechanisms.

3.1 Differences between absolute and relative formulas

Award mechanisms may be divided into two groups: the simple scoring rules ("absolute score") and the interdependent scoring rules ("relative score"). Scores of the award mechanisms from the first group do not depend on other bids. In the second group, the interdependent scoring rules, however, a competitor's score depends on other competitor's bids (Albano, 2014).

There has been discussions on using relative scoring methods for multiple reasons. Some disadvantages of relative scoring methods will be mentioned below (PIANOo, 2016):

- In case the relativity includes the price of bids, the market determines the scale of the price criteria
- There is a risk of ranking reversal

  However, in case 200-096-019, the court of Arnhem ruled that the ranking paradox itself is not a problem in tendering as long as you specify beforehand what you will do when a bid is disqualified after the ranking was made public. Otherwise, it is not transparent what you will do: recalculate of keep the initial ranking. Other court cases have already established that disqualified bids should not influence the ranking: so it is better to recalculate in general.
- It is possible to manipulate the tender
  - E.g. A supplier offering a high price may ask an accomplice to offer an extremely low price (and correspondingly low quality) to lower the weight of the price criteria. This is only possible in case of price-relative formulas.

The award mechanisms within the Negometrix platform may be divided as followed:

Absolute scoring rules	***Relative scoring rules***
Weighted Factor Method	NX Utility index
Value Based Awarding	Low Bid Scoring Formula
Value for money 50/50 Index	Rank on scores in survey

There are three formulas that need special attention considering relativeness. First, the NX Utility index may seem relative by the use of Q_{best} as well as P_{best}. However, P_{best} has no influence on the ranking. It is used as multiplier within the formula to get more readable outcomes. Negometrix has chosen to use P_{best} instead of a multiplier, such as within the value for money 50/50 Index method, to reduce the amount of parameters that a purchaser need to define in advance. Therefore, the disadvantages of relative formulas does not hold for the use of P_{best}, however, due to Q_{best} the disadvantages could still occur and the formula will be seen as a relative formula.

The other method that needs special attention is the rank on scores in survey method, which may not seem to be relative, since the score will be based on the individual quality of a tender. Although there is no ranking reversal, the method is still considered to be relative because the ranking is based on the relation between all offers.

Finally, a special variant on this division is the log formula. Although it contains P_{best} in its formula, the logarithmic scale ensures P scores on different bids do not depend on P_{best}. This results in the same mutual rankings, irrespectively of P_{best}. So, the disadvantages of a relative scoring method do not hold anymore.

Even though there is a change of rank reversal, this does not necessarily hold for all scoring rules. Different scoring rules may be divided as followed:

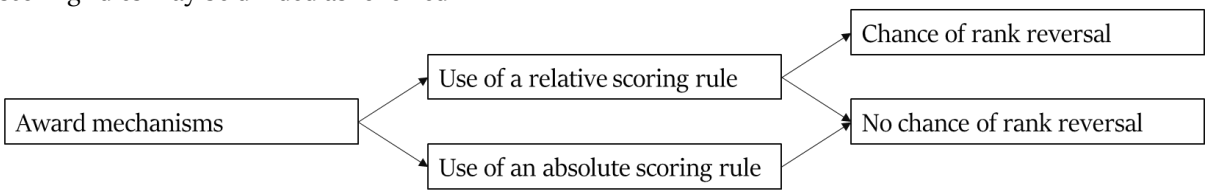


Figure 10: *Scoring rules and their chance of rank reversal*

Figure 10 shows that there are relative scoring formulas who do not have a chance of rank reversal. This will be formulas where the outcomes depend on other bids, but all outcomes will increase or decrease the same way. So the ranking will never change. Two examples of such relative scoring methods are the rank on scores in survey and the log formula.

A study of van den Engh (2017) compared three relative scoring rules in order to check whether rank reversal was possible. His study focused on a standard scoring method, a linear scoring method and the Staffel method. However, there was not enough data available about the Staffel to draw clear conclusions. His study showed that there is a bigger change of rank reversal when the standard method is used (P_{best}/P_i * WP) instead of the linear method (WP – WP*(Pi – P_{best} / (x-1)P_{best})). Therefore, it can be concluded that in case of Negometrix, there is a bigger chance of rank reversal when using the LBSF than using NX UI. In total, rank reversal may have happened 13.6% of the time. Therefore, it can be concluded that the chance of rank reversal is quite small. It only happens when two activities take place:

- An offer will be deleted, which in case of Negometrix is uncommon.
- There are offers with little difference in ranking.

It may happen that one of the activities occur, but the chance that both activities take place at the same time is very rare. Therefore, the use of relative formulas does not have to be avoided beforehand only considering rank reversal. It should also depend on other factors as well.

The study of van den Engh also showed that an increasing amount of suppliers participating in a tender also increases the chance of rank reversal and the use of a minimum quality (all offers that do not meet this quality level are not taken into account while ranking) decreases this chance. However, the use of a minimum amount of quality may have consequences for the weights of both quality and price.

Finally, it was concluded that the use of a relative scoring formula does not show any logic. To some extent, people entering a tender that uses a relative scoring rule are entering a lottery, where the outcomes may be influenced by a non-competitive supplier. However, results of the past show that there are almost never manipulative offers.

Other results of using a relative scoring rule is that competitors are not able to compute their score in advance and the procurer cannot fully determine the shape of the scoring curve in advance (Albano, 2014). However, in practice, no bidder can calculate his score because most criteria depend on the evaluation of the buyer. This evaluation can never be done before submitting a bid and without knowledge of the bids of other bidders (Negometrix, 2017). Secondly, an award system can only be fully transparent if the scores of a tender and a variant can be calculated beforehand, without knowledge on the other tenders. If relative scores are given, i.e. if the score of a tender depends on the other tenders, the system cannot be fully transparent (Chen, 2008).

However, there are some cases where the use of a relative formula is not discouraged. Firstly, when there is a certainty that only two suppliers will participate in the tender where only one price will be asked, the

disadvantages of the use of a relative formula will not hold. Using a relative formula will help to avoid determining difficult parameters where market knowledge is required. Secondly, the formulas may also be useful when there has been a preselection of suppliers, so there is no chance of unexpected offers.

3.2 A comparison of different award mechanisms

In *chapter 2*, it became clear that there are both differences as well as similarities that exist between the different award mechanisms. This subchapter compares the different formulas that show any similarities or may be considered relevant for comparison.

3.2.1 Comparison between NX UI and VFM

The first comparison will be done based on the NX Utility Index and the value for money 50/50 index method. To do this, both formulas will be compared to each other.

The formula of Equation (1) may be rewritten to Equation (19) (see *Appendix III: All intermediate steps in rewriting formulas*).

$$u = \frac{Pbest}{Pi} - \frac{WQ*(Qbest-Qi)}{WP*Pi} * P_{best} \tag{19}$$

The rewritten formula shows that the formula of VFM (Q/P) is used to develop NX UI with a slight difference to add weights to both quality and price (avoid the 50/50 index) and multiply the outcome with P_{best}. Another difference with VFM is the addition of a price score, to avoid that the total score will be enormously small. So it can be concluded that the NX Utility Index is a derivative of the value for money 50/50 index method with some adjustments to make it possible for buyers to determine their own quality to price ratio's.

3.2.2 Comparison between WFM, LBSF and LOG

As already mentioned, the formulas of those award mechanisms all sum up a score of price to a score of quality. Since this is equal to the definition of the function of the Weighted Factor Method, all three award mechanisms may be regarded as a form of the Weighted Factor Method with different scoring rules. The expressions for WFM, LBSF and LOG are shown below in respectively Equation (20), Equation (21) and Equation (22):

$$WFM = WQ * Q_i + WP * ((P_{setmax} - P_i)/(P_{setmax} - P_{setmin}) \tag{20}$$

$$LBSF = WQ * Qi + WP * \frac{P_{best}}{P_i} \tag{21}$$

$$LOG = WQ * Q_i + WP \left(1 - \frac{\log\left(\frac{P_i}{P_{best}}\right)}{\log(A)}\right) \tag{22}$$

As one can see, all scores for quality have been determined in the same way. However, the scoring rule to determine the price score differs substantially. The most remarkable aspect is that the WFM as mentioned within the Negometrix platform is an absolute formula, whereas the LBSF is a relative formula and the LOG is a combination of both. This is the main difference between the three award mechanisms.

Rewriting any of those award mechanisms is not relevant to see the link between the award mechanisms, since the scoring rules differ from each other. However, it is the case that every price scoring rule contains at least one division and more importantly, both the LBSF and LOG formula are using $\frac{P_{best}}{P_i}$. This may be a reason to conclude that Chen has used the Low Bid Scoring Formula and adjusted it to avoid the ranking reversal as already mentioned in subchapter *2.5 Log fomula*. He uses *A* to create a possibility to influence the scatter of the price which avoids a final outcome that is mainly determined by the best price. Additionally,

this could be a reason for the similarities between the graphs of the Low Bid Scoring Formula and the log formula (both curved lines).

To conclude, the Weighted Factor Method, as well as the Low Bid Scoring Formula and the log formula all follow the WFM method with their own scoring rules for price. The method that needs to be used depends on the preference for an absolute formula, a relative formula, or a combination of both.

3.2.3 Comparison between WFM and VBA

Only considering the formulas of the Weighted Factor Method and Value Based Awarding does not show clear similarities. However, the graphs following from the formulas are similar. Therefore, a comparison between the formulas will be made.

According to Sciancalepore and Telgen (2011) there is a mathematical equivalence between the Weighted Factor Method and Value Based Awarding. They assume it is possible to build an WFM evaluation that ranks the bids in the same way as VBA and in reverse, irrespective of the specific bids involved. However, there is a restriction; a linear scoring function for price should be used in the Weighted Factor Method. This is equal to Equation (7) and may be rewritten to Equation (23).

$$Pscore = a - b*P_i \ , \qquad a, b > 0 \tag{23}$$

The formula used by Scinacalepore and Telgen to determine the score of quality is equal to the expression shown in Equation (24).

$$Q_i = \frac{Q_i - Q_{min}}{Q_{max} - Q_{min}} \tag{24}$$

Where bids with Qi < Qmin are rejected.

When the WFM is applied, there is a need to find a bid i that maximizes Equation (25).

$$\max(WP * P_i + WQ * \ Q_i) = \max(WP(a - b * P_i) + WQ * Q_i. \tag{25}$$

To be able to establish the equivalence between WFM and VBA, there should be a Q_{set} directly calculated from WP and WQ, such that the maximum is always attained at the same bid i, irrespective of the bid set. Therefore, Q_{set} should relate to WP and WQ such that Equation (26) holds.

$$\min\left(P_i - Q_{set_i}\right) \leftrightarrow \max\left(-P_i + Q_{set_i}\right) \leftrightarrow \max(WP(a - b * P_i) + WQ * Q_i \tag{26}$$

Where Equation (26) may be rewritten as Equation (27)

$$-WP * b * P_i + WQ * Q_i + WP * a \tag{27}$$

The maximization of a linear function is not dependent on fixed terms, therefore the formula may be reduced to Equation (28)

$$\max\left(-P_i * Q_{set_i}\right) \leftrightarrow \max(-WP * b * P_i + WQ * Q_i) \tag{28}$$

Both terms are linear functions, they attain their maximum value for the same bid i if the ratio among the coefficients of the linear functions is equal. These coefficients assume that Q_{set} may be calculated with Equation (29).

$$Qset = \frac{WQ}{WP*b} \tag{29}$$

Now that the formula of Q_{set} is known, it may be simple to translate a WFM award mechanism into an VBA award mechanisms.

According to Sciancalepore and Telgen (2011), it can be noticed that there are ∞^2 combinations (*WP, WQ, b*) according to which a given VBA can be translated into WFM for the given Q_{set} . This amount may be reduced by remembering that the sum of *WP* and *WQ* is equal to one in WFM. As a result, weights in WFM that make it equal to VBA can be determined by solving the following linear equations system (30):

$$\begin{cases} WP * b = \frac{WQ}{Q_{set}} \\ WP + WQ = 1 \end{cases} = \begin{cases} WP = \frac{1}{b*Q_{set}Q+1} \\ WQ = \frac{b*Q_{set}}{b*Q_{set}+1} \end{cases} \tag{30}$$

There are still many combinations possible due to the freedom of Q_{set} and *b*, but this freedom can be eliminated by appropriately setting parameter *b*.

It might be useful to remember that in the WFM, the magnitude of the price score is affected by both *WP* and coefficient *b*. Therefore, shifting from VBA to WFM, *WP* and *WQ* does not only depend on Q_{set}, but also on the scaling of coefficient *b*: the larger the *b*, the smaller *WP* and the larger *WQ*. Simultaneously, if *WP* and *WQ* are used to determine Q_{set} in order to apply VBA, buyers should note that Q_{set} depends on *WP* and *WQ*, but also on the balance between *b* and *WP*.

Concluding, the formulas are not the same, but there is an opportunity to easily shift from WFM to VBA and the other way around, by calculating parameters based on the information already known from the other method when a linear scoring function for price is used. As a result, bids will be evaluated with the same ranking.

4. Situation Negometrix

4.1 How are buyers supported in choosing an award mechanism nowadays?

In the current situation, Negometrix is one of the few platforms that integrated different award mechanisms and their corresponding formulas in ready to use online workflows. As a result, there are more opportunities to get to support and the ability to offer a structured workflow. Their support consists of an Excel file where it is possible to see and evaluate the differences between the formulas allowing the buyer to enter bids and parameters and compare the ranking which is graphically supported by iso-utility. In addition, there are separate documents that try to explain the most difficult aspects of their system and the most used formulas. Also, when a buyer enters the system and needs to choose an award mechanism, there is a question mark available which provides some information. This information is equal to:
You have chosen to tick the "Weighted" option. This will provide you with an indication to measure the quality of suppliers. The "Negometrix Utility Index" is a relative formula that presents the offer with the highest utility as the best buy. The "Weighted Factor Method" provides the purchaser with control in determining how much the tender will be affected by price over quality. Value Based Awarding asks you to specify the weight in a monetary amount. The quality and price will then be combined into a single monetary value to determine the best buy (Negometrix, 2015).

As one can see, three out of seven award mechanisms are explained a bit. However, some buyers have asked for more support to make a well-considered choice between the seven award mechanisms when they are not aware of all options and their corresponding characteristics. Additionally, the three award mechanisms need to be explained more extensively to let buyers fully understand the award mechanisms. So they have made a start in offering support, but within this aspect there is room for improvement.

Finally, buyers can simulate already finished tenders and re-enter the parameters and see corresponding changes.

As already mentioned, Negometrix also uploaded instruction documents to get familiar with the award mechanisms. Buyers will be notified on the presence of those documents with release notes within the platform. Additionally, Negometrix offers courses to buyers in order to get familiar with the software. It may have added value to notify buyers on the presence of all support documents within those courses as well.

There are differences between the English and the Dutch documents available. The English documents only provide information about the WFM, the VBA and the NX UI. The Dutch documents also provide information on the other award mechanisms. Yet, there is an Excel sheet available, the EMVI calculation sheet, which mentions the formulas of all award mechanisms (except the rank on scores in surveys) and allow buyers to play with numbers to see differences between the award mechanisms.

One disadvantage of this Excel sheet, especially for Dutch buyers, is the language used within the Excel sheet. All information within the sheet is available in English. The responsible manager of Negometrix told me that this disadvantage caused some complaints from (Dutch) buyers. So this aspect should be taken into account when developing support for buyers. In addition, there is room for improvement within the Excel file: it should be more adjustable (buyers that want to add an additional offer do not have that possibility within the sheet yet) and the differences may be shown in a clear graphical way. Besides these documents and the little explanations within the platform, there are opportunities to develop additional support to help buyers to make their decision between the different award mechanisms as well.

When the decision is made and the buyer has chosen one option, the next step for the buyer is to fill in the parameters to allow the platform to calculate the outcome. The parameters that need to be defined by the buyer within the platform are:

Award mechanism	***Parameters***
NX Utility index	〉 Price-quality ratio 〉 Weights to questions (to determine quality)
Weighted Factor Method	〉 Price-quality ratio 〉 Maximum and minimum prices (and say if it is allowed for the prices to be higher or lower: allow prices < max score bid, allow prices > min score bid) 〉 Weights to questions
Value Based Awarding	〉 Give weights to questions in money (€)
Low Bid Scoring Formula	〉 Price-quality ratio 〉 Weights to questions (distribution of weights: group weight: set weight manually or group weight: the sum of weight questions)
Log formula	〉 Price-quality ratio 〉 Set a score on which price receives zero points (what multiple of the lowest price leads to a zero price score) 〉 Weights to questions
Value for money 50/50 index	〉 Price-quality ratio 〉 A multiplier in order to give well-readable numbers 〉 Weights to questions
Rank on scores in survey	〉 Weights to questions 〉 A price score into one of the questions of the survey

It looks like some award mechanisms do have more parameters that need to be defined by the buyer on forehand. The NX UI has one parameter less in comparison to VFM, it uses P_{best} instead of a multiplier. Since this is also a possibility for the formula of VFM, it may be considered that NX UI and VFM both have two parameters that need to be defined. However, the only customer-user has insisted the multiplier. In addition to this remark, it should be noted that the number of parameters is not an indication on how well the award mechanism functions. An award mechanism with four parameters may fit the situation better than an award mechanism with only two parameters. Although fewer errors can be made when less parameters need to be defined, this does not mean the award mechanism fits the situation best, so buyers need to be aware of this.

Currently, the only descriptions on the different parameters available within the system are:

Award mechanism - Parameter	***Support or requirement***
Weighted Factor Method – max/min price	Price in maximum score field should be lower than the price in minimum score field
Log Formula - A	Multiple of the lowest price leading to 0% of price score
Value for money 50/50 index - multiplier	The multiplier should be greater than 1
All – Distribution of weigths	If you choose the first option it allows you to set weights for each group and for individual questions. The second option allows you to set weights only at the group level. The system automatically tallies the total amount of the weight per question group.

As one can see, Negometrix offers support to its buyers to make the different award mechanisms understandable, but there are opportunities to improve the available information and to focus more deeply on the choice between the different award mechanisms.

4.2 How are the award mechanisms used in the current situation?

There are seven award mechanisms implemented in the Negometrix platform. However, they are not implemented at the same time, therefore a timeline is shown in Figure 11 to give an overview on the chronological order in which the award mechanisms have been implemented into the system.

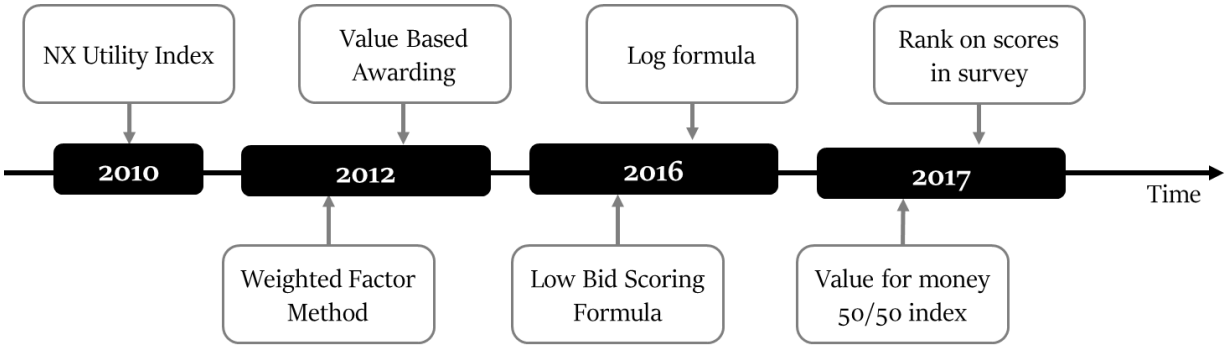


Figure 11: *Timeline of the implementation of award mechanisms into the Negometrix platform*

Due to the different implementation dates it is not possible to derive ratio's on the utilization frequency of each award mechanism. Therefore, the tenders are divided into three phases (2012-2015, 2016 and 2017), wherein each phase involves the implementation of (a) new award mechanism(s). The number of times that an award mechanism is used can be found in Figure 12.

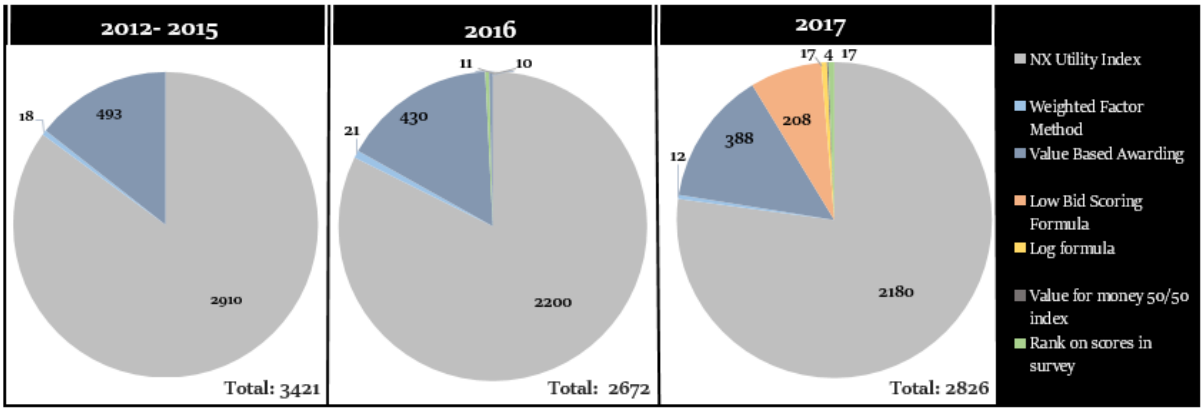


Figure 12: *The number of times that several award mechanisms were used in the Negometrix platform*

As one can see in the pie diagrams, the NX Utility Index is by far the most used award mechanism at Negometrix. One possible reason for this relatively high degree of utilization is the fact that the NX Utility Index was implemented first. Customers were already using the method and may not like to change their habits since the method is providing them a solution. This outcome may also be a result of the recommendations from Negometrix to use this method, since they picked up the formula from the Italian public procurement practice in 2000 and consider it to be useful. Additionally, the understanding of the method may be a reason to use it, since it does not involve difficult parameters.

The next step will be comparing the ratios of the different award mechanisms. First of all, the award mechanisms that have been implemented from 2012 (or 2010) were taken into account. However, the ratios remained quite similar. Therefore, they will not be mentioned at all. The next analysis will be done based on the ratios of 2016 and 2017, as a result of the increasing number of award mechanisms. This results clearer differences and therefore the results will be displayed in Figure 13.

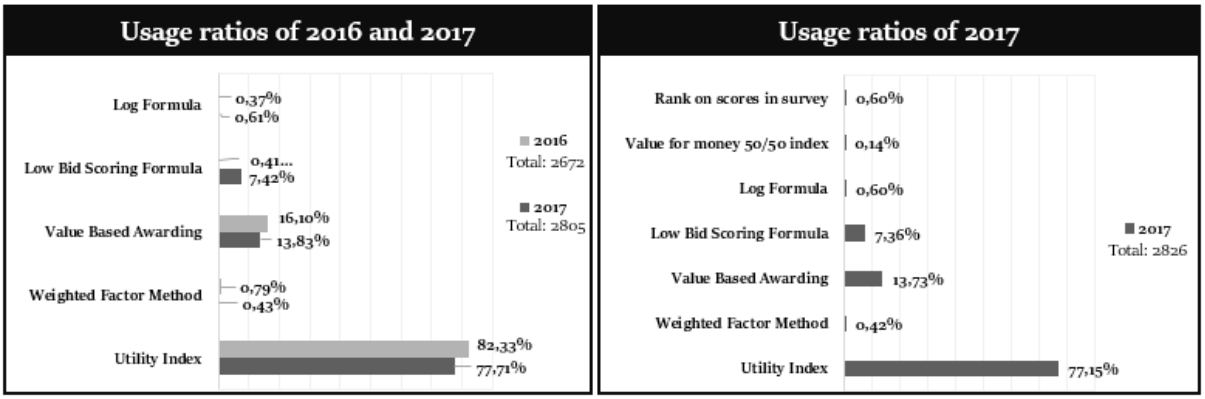


Figure 13: *The usage ratios of the different award mechanisms that were used in the Negometrix platform*

The most remarkable aspect of this comparison is the increasing use of the Low Bid Scoring Formula. Apparently, more people are willing to deviate from using the NX Utility index and the comparison shows that the Low Bid Scoring Formula becomes more popular. It also looks like the Value Based Awarding method and the Weighted Factor Method become less popular. Therefore, we need to find out the aspects of those methods in order to determine why the popularity is increasing or decreasing.

Additionally, ratios could be determined in the year 2017. This is the first and only year available to determine a ratio between the seven implemented award mechanisms. It should be noted, however, that the year has not been finished yet. Therefore, ratios could change during the year. Nevertheless, the data has been used to give an overview of the ratios when all award mechanisms have been implemented.

It is clear that the NX Utility Index has been used the most in the past, but the number of buyers choosing another award mechanism is on the rise. Therefore, no clear conclusion could be drawn on how the mechanisms will be used in the future. Additionally, it proves that more people are willing to choose another method and the implementation of a support system gives the opportunity to help them in making a well-considered choice which could change the ratio's.

4.3 Are buyers asking for support on award mechanisms?

One way of creating an image of the number of buyers facing difficulties in choosing the right award mechanisms is looking at the calls received by the service desks. These calls contain questions about subjects that buyers need support with the way the award mechanisms are currently shown. In order to create this image, data was gained from the service desk. This resulted in an Excel file which summarizes all calls to the service desks and their corresponding subjects. The data concerns calls from thirty days before the 9th of May (the day the data was obtained). The data is filtered to buyers, which brings the total number to 2391 calls, of which 198 calls are not linked to a subject at all. However, this includes many subjects that are not relevant to consider. Therefore, only subjects that are considered to be relevant in choosing the right award mechanism are taken into account. Those subjects are equal to: Award, BAFO (best and final offer), BAFO-evaluation, evaluation (incl. price evaluation), KPI evaluation, selection, selection evaluation and selection verification. There is a total of 516 calls that are part of subjects that are somehow linked to the award mechanisms and can be found in *Appendix IV: All buyer calls (complaints) considered to be relevant.*

Ignoring the calls that are not specifically linked leaves that number to 482 calls. This number tells us that almost 22 percent (482 / 2193*100%) is linked to evaluating tenders. Nevertheless, it has to be taken into account that a huge part of those calls originates from changes within the system or misunderstanding of the system. So the part directly linked to award mechanisms is even smaller. To get a realistic view, the data will be analysed even deeper and only the subjects that are linked to the award mechanisms or support by making a decision will be taken along.

Subject	**Amount**
Support	33
Export	21
Evaluate	18
Visibility	7
Content	6
Manage	4
Select	3
Assign	2
Total	94 ≈ **4%** of the total amount of calls

Besides the previous mentioned analyses, there is an option to specifically search for the tag 'formula' within the calls. In that case, no distinciton is made between suppliers and buyers. As a result, there is a total of 3618 calls where only 8 calls are linked to the tag 'formula'. This is equal to approximately 0,2%.

Considering these analyses may provide a remarkable conclusion: There is relatively little help needed from Negometrix for buyers in making their decision between different award mechanisms. This conclusion raises a couple of questions:

- To what extent are buyers curious about the differences between the different award mechanisms? Are they choosing the first option in order to avoid difficulties? Are they choosing the same option every time?
- To what extent are buyers educated? Do they know all award mechanisms already? Are they aware of differences between the award mechanisms?
- Are buyers asking their help intern ally instead of using the Negometrix service desk?

All questions should be answered by taking interviews with buyers and will be elaborated in a later chapter. So a logical reason for Negometrix to offer little support is an apparent absence of visible difficulties from the buyers perspective, based on the data from the sevice desk.

4.4 How do buyers react to the existing platform and the corresponding award mechanisms?

This chapter will involve buyers to get insight on important aspects that should be considered in order to develop support for buyers. First of all, the methodology used will be described. Thereafter, a summary of the interviews linked to the related research questions will be given.

4.4.1 What methodology is used to conduct the interviews?

To get to a solution which is helpful for all buyers using the Negometrix platform, it is essential to involve buyers (or procurement advisors) who use the Negometrix platform. Therefore, five in-depth interviews will be conducted.

The in-depth interviews are based on a methodology described by Cooper and Schindler (2014). The communication approaches were prescheduled personal interviews in a participant-controlled environment. So the buyers were able to choose the interview location of their preference. As a result, the author has travelled throughout the country to be able to have face to face interviews.

It should be noted, however, that there is a possibility to have errors using this communication approach. Errors could occur as a result of a sampling error, a data entry error and process errors. Before having the interviews it should be checked whether the interviews are consistent and the environment is not influencing the answers of participants. Additionally, errors may also occur due to misunderstandings of participants. They may have a lack of knowledge or misinterpret information. These factors should be taken into account while having in-depth interviews.

The motivation of participants should also be considered. The motivation of buyers may be influenced by several factors which may be summarized as (Cooper and Schindler, 2014):

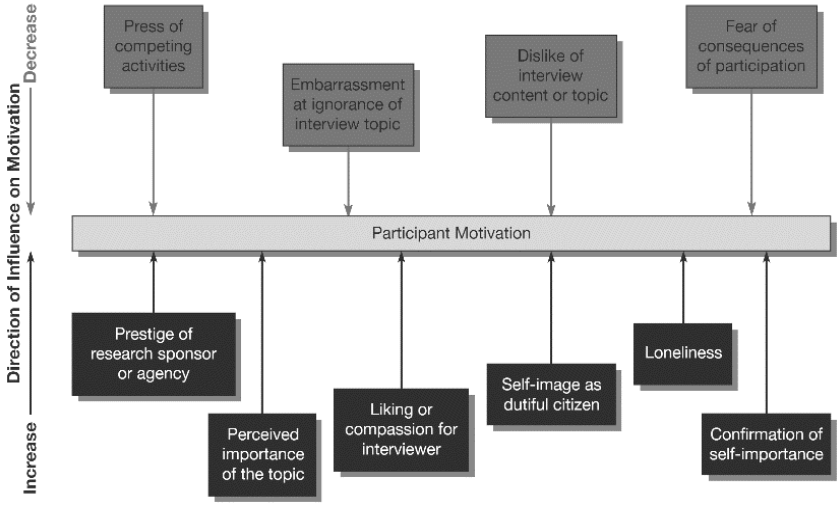


***Figure 14**: Factors influencing participant motivation*

So, in order to approach participants that will be useful for the research, it is necessary to check whether they are interested in the topic and to show them the added value they gain from participating in the project. It should be clear that the interviews are on a voluntary basis, whereby the buyer is able to stop participating or change his answers at any time during this research. These activities should ensure that there as less errors as possible in conducting the interviews.

There are both advantages as well as limitations by having personal interviews. The most important advantage is the depth of information and detail that can be secured. Interviewers can note conditions of the interview, probe with additional questions, and gather supplemental information through observation. Additionally, there is an option to pre-screen to ensure the right participants are involved. However, one big disadvantage of personal interviews is the high costs that are involved, in terms of both money and time.

Finally, the kind of questions that will be held during the interviews will be described. There are two types of questions; closed-ended questions and open-ended questions (Farrell, 2016). Both dealing with advantages as well as disadvantages which will be mentioned below:

Closed-ended questions		**Open-ended questions**	
Advantages	***Disadvantages***	***Advantages***	***Disadvantages***
It allows you to find more than you anticipate	Answers from participants may differ a lot and be therefore incomparable	You get higher response rates in online interviews (it takes less time for participants)	Those questions stop the conversations and eliminates surprises.
Allows participants to give a free-form answer		The answers can easily be analysed statistically	You may limit participants to answers you defined

			The questions may bias someone into giving a certain response

It is possible to combine both open-ended and closed-ended questions into an interview. Because it concerns a qualitative research instead of an quantitative research, it is best to use open-ended questions. However, it may have added value to start with open-ended questions and move slowly towards closed-ended questions. This implies that you start with giving freedom to the participants to tell all aspects that they consider to be relevant, followed by being more specific and ask closed-ended questions whether they think additional aspects are useful even though they did not mention it. The subjects that will be handled during the interviews are: kind of buyers (including sort of purchases), experiences with the Negometrix platform, awareness of the different award mechanisms and preferences for support. Combining all components mentioned in this subchapter will provide the method that will be used during the interviews.

4.4.2 A summary of the five in-depth interviews

The five in-depth interviews have been conducted with participants varying from a hospital to a bank in order to get an overview of the different kind of buyers and how they would like to be supported in the near future.

The first paragraph is answering the research question: *Are buyers facing difficulties in choosing an award mechanism?* It becomes clear that there is no specific type of customers at Negometrix. Therefore, it should be kept in mind that the support system must be usable by different types of buyers. In particular, buyers are not interested in understanding the different award mechanisms and their corresponding characteristics due to the fact that they are not aware of the influence on the outcome. They will use a method which has been used since the beginning and are not willing to change the method without an in-depth understanding of the other award mechanisms. However, they do not want to spend a lot of time in order to get to that in-depth understanding either. Additionally, a lot of buyers are copying activities of buyers in their surroundings, based on the idea that what their partners or competitors are doing is correct. However, it differs per purchase how to handle the situation. This applies especially to buyers who are not mathematically educated and are not able to analyse the formulas themselves. In conclusion, buyers who face difficulties in choosing the best award mechanism ease their choice by copying procurement processes which they are familiar with, even though they do not fully understand that award mechanism. This shows that it is important to develop support to give buyers an in-depth understanding of the different award mechanisms without spending too much time.

This paragraph answers the research question: *What award mechanism do buyers normally use? And why?* Answers given in the interviews show that there is a striking difference between the formulas used in the different branches. Where the bank likes to use the log formula, the hospital prefers to use the Weighted Factor Method. However, most of the time the NX Utility Index has been used. The reason for using the NX UI is the presence of a desired price-quality ratio and the easiness of explaining it to suppliers according to the buyers. It is mandatory to communicate to suppliers why they have won, but more importantly to the losing parties why they have lost, based on the used formula. Therefore, the 'easiness' of the formula, and the buyers' familiarity with the award mechanism cause most buyers to choose the NX Utility Index. They have become accustomed to the Utility Index, since it was the only method available from the first usage of the platform in 2010 until 2012. As mentioned earlier, the bank uses the log formula. The reason for using this method is the ability to vary *A* to make the graphic steeper and to give price more power. They do not want to use the best price, since they are focusing on quality most of the time, because they want to have a good combination between price and quality. Lastly, the hospital is using the Weighted Factor Method, because they are able to determine the weights themselves and give an enormous focus on quality.

The third research question that will be handled is: *In what way do customers like to see the differences between the different award mechanisms?* The interviews made clear that all buyers prefer to see a graphical support in order to get an in-depth understanding of the different award mechanisms, because visualization helps to get a better understanding. However, there is added value in making a combination of visualizations with calculations and explanations to satisfy all buyers. Some buyers told me that they would like to be able to play with the formula and their corresponding parameters in order to get a better understanding, therefore calculations need to be involved. Additionally, buyers who do not understand the mathematical formulas prefer to have an explanation of the different parameters and the overall functioning of the formula. It is best to make a distinction between the different types of support, so buyers do have the ability to choose the support that fits their needs. In addition, there must be a possibility to compare the different award mechanism and there must be an option to choose one of the methods and be able to play with it.

The fourth and last research question that will be answered is: *What kind of support are customers looking for in choosing between different award mechanisms?* This results in the following comments that should be taken into account when developing a support system:

- Some of the buyers make a preselection of suppliers and continue the procurement process by only taking those suppliers into account when using the award mechanism. Hereby, they hope to avoid suppliers to offer an unrealistic price or quality which they cannot really offer. Additionally, they would like to get advice on which supplier to contract based on the chosen award mechanism. However, they still want to be able to check everything and have the possibility to calculate with the data themselves. They want to understand and check the final decision on which supplier will be contracted. Also in case multiple suppliers are granted.
- One main disadvantage of the Value Based Awarding method is the determination of Q_{set}. Most of the time it is unclear how much money will be saved by getting more quality. Because buyers have to deal with different procurements, one cannot have knowledge about all aspects, and therefore it is hard to determine reference values. So, it may be useful when there is support on how to determine Q_{set}. However, it will be best when this support comes from end-users on the buyer side.
- According to one of the buyers, not all terms in the platform are logical for people doing European procurements. So the terms used in the support need to make sense. When the support is developed, it must be placed in a logical place. Within the system there is a possibility to click on a question mark button to get more information, so there is an opportunity to link to external documents.
- According to buyers, it is important to offer offline support besides the online support developed within this thesis. This will include notifying all employees and make sure they are able to help buyers in making their choice between the different award mechanisms or give the opportunity to let buyers follow tutorials, which will mention all award mechanisms and their corresponding characteristics.

5. Characteristics to develop a decision support system

This chapter will map characteristics and requirements that should be taken into account when developing a decision support model. All characteristics found in literature that are considered to be relevant will be mentioned.

5.1 How to choose an award mechanism according to theory?

According to Meijer and Telgen (2007), weights are known from the start in most cases, however the underlying method is often unknown. The underlying method depends on (one of) three factors: the relation between scores and weights, the interpolation of scores and relative scores. The outcome is not based on weights alone, therefore it is important to underpin the chosen weights by making the underlying method public. Hereby it can be avoided that the outcome will be influenced to let the desired candidate win the tender, because the application of another method led to another winner. Therefore, it may be concluded that it is best to do a scenario-analysis on forehand to check whether the desired effect will be reached with the chosen method. Additionally, it may be useful to use a fixed formula for interpolation as part of the scoring methodology and determine it in advance to avoid changing outcomes. Finally, buyers should be aware of the discussion on using relative formulas versus using predetermined standards to ensure the outcomes do not make unexpected changes after removing other bids. When choosing the underlying method, buyers need to keep in mind that the purpose of award mechanisms is to align the procurer's needs and preferences with competitor's incentives to compete on price and quality (Albano, 2014).

The preferences of the buyer are described in award mechanisms by:

- Capturing the buyer's evaluation of technical and economic attributes of submitted tenders
- The award mechanism represents the tension (trade-off) between price and quality
- The award mechanism ensures that the contract is awarded to the tender which is the best to meet the buyer's requirements

Albano (2014) advices to start with carefully doing a market analysis and simulations based on hypothesis on the possible tenders before choosing an award mechanism. Followed by considering the full scoring scheme together (joint evaluation of price bids and technical criteria). When there is certainty on how to provide a monetary evaluation of the economic value of quality award criteria it is best to use an absolute scoring rule.

Award mechanisms are crucial to align the incentives to competition with the buyer's needs and preferences. But any effort to design an effective scoring mechanism is useless without proper contract design and contract management. Scoring rules define buyer's preferences and help management of the contract when quality is verifiable.

To decide which award mechanism to use there is a requirement to do an evaluation on the contracting authorities' needs and be aware of market prices.

5.2 What are the characteristics to develop a decision support system following the theory?

First of all, it may be helpful to get an understanding on 'decisions'. According to Buchanan and O'Connell (2006), a decision implies the end of deliberation and the beginning of action. Where risk is an inescapable part of every decision. Even in win-win situations there are costs in the form of opportunities that are not taken.

In many cases decision makers do have a good reason to prefer instinct. One study of Jagdish Parisk conducted at Harvard Business School show that people used their intuitive skills as much as they used their analytical abilities, but eighty percent of their success wat credited to their instinct. Additionally, Henry Mintzberg

explained that strategic thinking cries out for creativity and synthesis and thus is better suited to intuition than to analysis.

Now that it is clear what a decision is, the next step is to find out some characteristics of a decision support system. Decision support systems (DSS) contain three characteristics that distinguish them from other information systems. First, a DSS helps managers in decision making. Secondly, a DSS uses sophisticated modelling techniques and lastly, DSS are built with specialized tools that allow the design of flexible systems at low costs (Casimir, 1988).

The concept of DSS is originated by Scott Morton in the early 70's and tells that DSS are categorized as a specific group of computerized information systems that supports management decision making activities. It tries to analyse strategic decisions to offer support in a complex and poorly structured situation. Some advantages of using a DSS is that is assists through the decision making process and improves the quality of the decision process. The concept follows from a balance between human judgement and information process by a computer. A DSS contains three fundamental components: a database management system (data bank for DSS), model-based management system (also to provide data) and the method of dialog generation and management system (Yazdani et al, 2017).

According to Ralph and Sprague (1980), there are some characteristics of a DSS followed from a research of Alter, Keen and others:

- A DSS aims at underspecified problems and is decision focused.
- A DSS attempts to combine the use of models with traditional data access and retrieval functions.
- A DSS ensures it is usable for non-computer people in an interactive mode (user initiated/controlled).
- A DSS emphasises adaptability, flexibility and quick response.
- A DSS offers support for personal decision making styles.

In this article, it is also mentioned that a DSS need to be built with short, rapid feedback from users to ensure that development is proceeding correctly. It must be developed to permit change quickly and easily. In order to do that, there are some characteristics that should be taken into account. It may not possible to fulfill them all at the same time, however, they should at least be considered.

- A DSS should provide support for decision making, but with emphasis on semi-structured and unstructured decisions.
- A DSS should provide decision making support for managers at all levels, assisting in integration between the levels whenever appropriate.
- A DSS should support decisions which are interdependent as well as those that are independent.
- A DSS should support all phases of the decision making process.
- A DSS should support a variety of decision making processes, but not be dependent on any one.
- Finally, a DSS should be easy to use.

Finally, the way we are using a DSS and its usefulness is based on three different aspects:

- The action language; what language is used to interact with the DSS?
- The display or presentation language; what does the DSS look like and is it understandable?
- The knowledge base; what knowledge is required in order to use the DSS?

All characteristics and aspects that are used to describe a decision support system should be taken into account while developing the support system for buyers. If the support system is missing some characteristics, it may happen that it does not fully support buyers in making their decision between the different award mechanisms. However, it should be noted that this report is trying to offer full support and is not only focusing on the development of a decision support system.

6. Development of a support system (SS)

First of all, I want to show the importance of the decision between different award mechanisms. Therefore, all award mechanisms are compared to each other, which shows that the ranking may change when certain bids are offered. Examples to prove this can be found in *Appendix V: Another award mechanism may change the ranking*.

Secondly, as shown in chapter *3.2 A comparison of different award mechanisms,* it is possible to rewrite parameters in order to get parameters of another award mechanism. This has been proven for WFM and VBA by Sciancalepore and Telgen (2011). This will ensure that all bids will be ranked in the same way, irrespective of specific bids involved. Therefore, it can be concluded that one cannot exclude an award mechanism just by its parameters, because there may be other ways to calculate them.

Taking this aspect into account shows that one cannot exclude award mechanisms due to the difficultness of its parameters. Therefore, it is important to look at other factors to help buyers in making their decision between different award mechanisms. This is the reason why the decision has been made to focus on characteristics of the award mechanisms and let buyers be able to play with the different formulas to develop the support system.

Three types of support have been developed in order to help buyers in their decision between the different award mechanisms. The first kind of support will be decision trees based on characteristics of the different award mechanisms. However, the decision trees will not get to one specific award mechanism, because they will ensure that buyers still have the freedom to choose themselves, but it helps them eliminate irrelevant award mechanisms in a certain case. The decision trees are divided into four subjects: relativeness, price, price/quality ratio and quality. Therefore, buyers are able to select a subject that they consider to be relevant and follow the decision tree to eliminate irrelevant award mechanisms. It is also possible to follow several decision trees and take the award mechanisms that most often served as outcome into account in making the decision between the different methods. The decision trees are as followed:

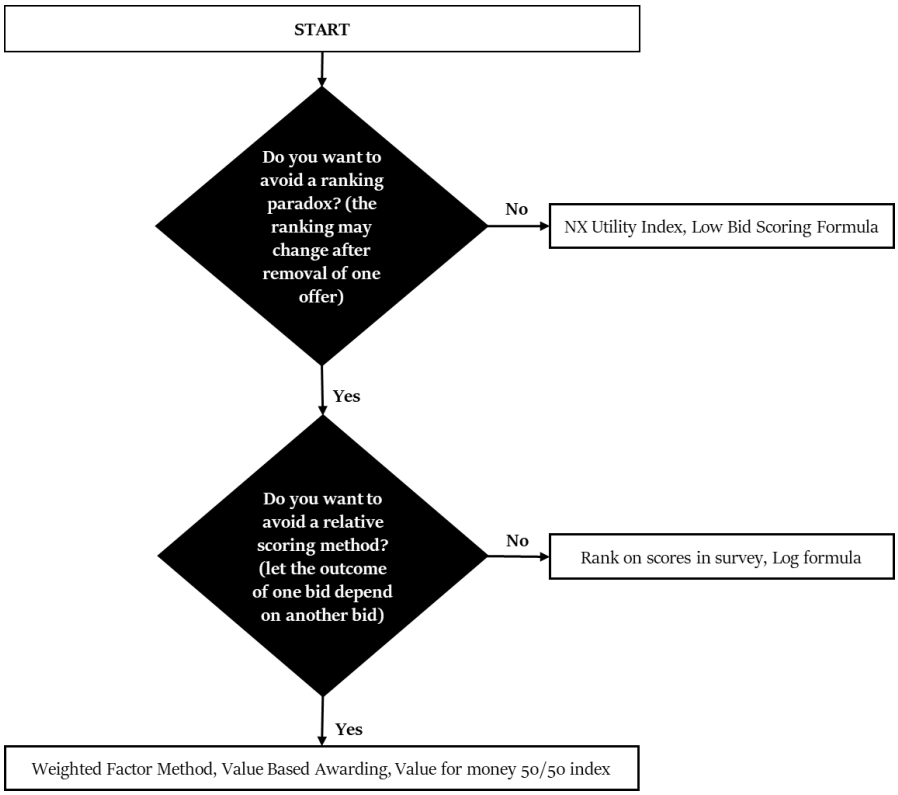


***Figure 15**: Decision tree related to relativeness of award mechanisms*

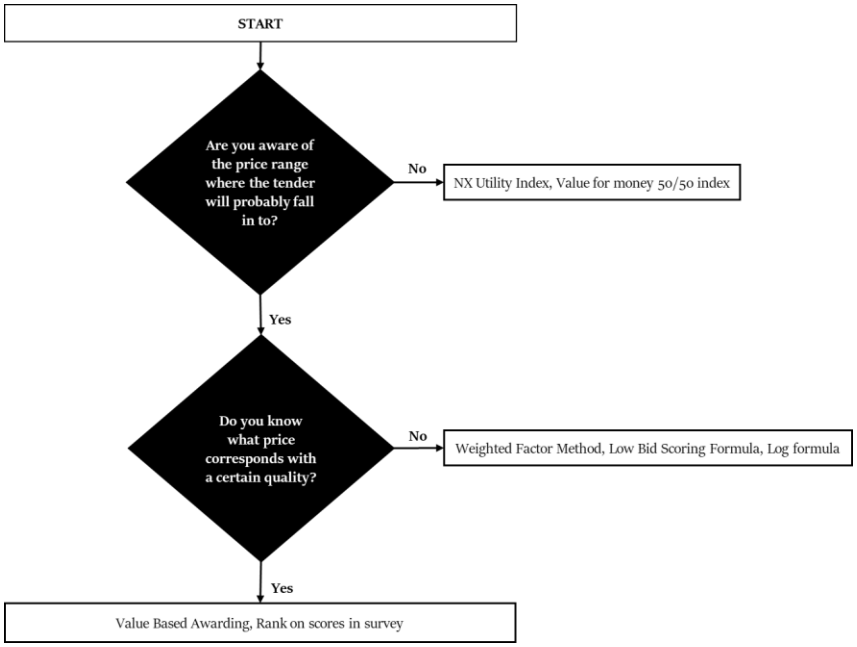


***Figure 16**: Decision tree related to expertise in price*

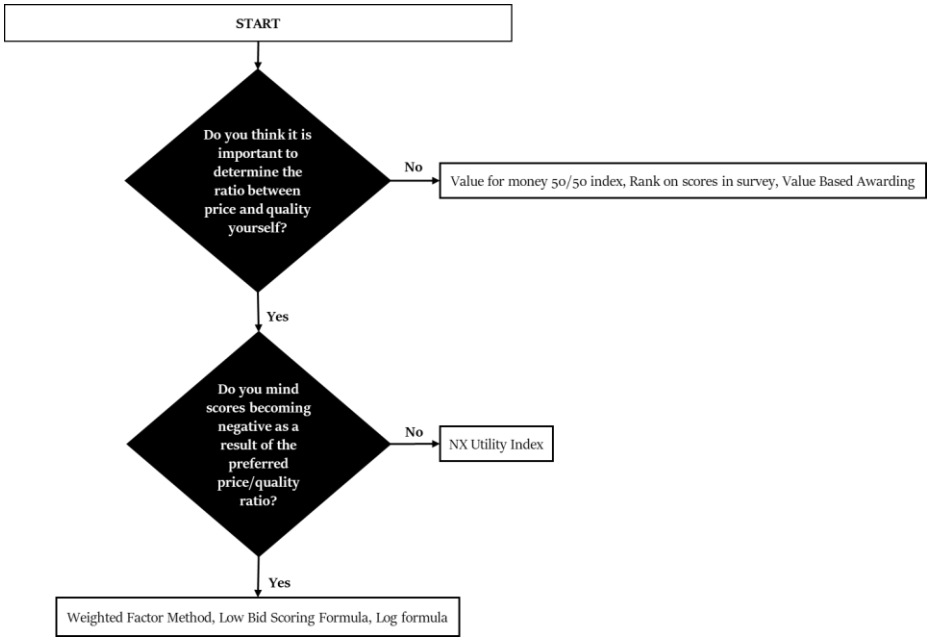


***Figure 17**: Decision tree related to the ratio between price and quality*

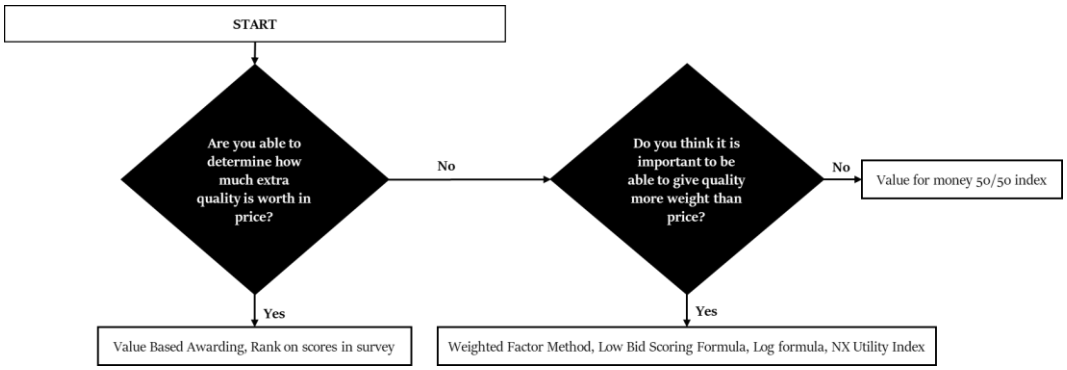


***Figure 18**: Decision tree related to expertise in quality*

As mentioned in chapter *5. Characteristics to develop a decision support system,* it is important to do an evaluation on the contracting authorities' needs and be aware of market prices before choosing an award mechanism. However, a buyer may lack in doing this activity as a result of little time. This leaves two options: let somebody else do the analysis on the contracting authorities' needs and market or use an award mechanism that does not require knowledge of the market. With the use of relative formulas the market fills in all parameters, so there is no need to be aware of market prices. But on the other hand, when using relative formulas, there is a small change of ranking reversal, which may result in undesired charges. Additionally, as a result of using relative formulas the tender is not fully transparent, since the outcome depends on other offers as well. Therefore, suppliers are not able to calculate their most optimal offer, since there are numbers that may change. However, relative formulas may be useful when there was a preselection to select suppliers that are able to participate in the tender, which ensures that there are no extreme, unrealistic offers. So it is depending on the situation whether or not to choose an relative award mechanism. Those aspects should be taken into account while using the decision trees.

The next part support that will be offered is the option for buyers to make a preference curve and compare it to the different award mechanisms, to choose the award mechanisms that looks similar to the preference curve. The preference curve will be made based on the willingness of buyers to pay a certain price. An example can be found below:

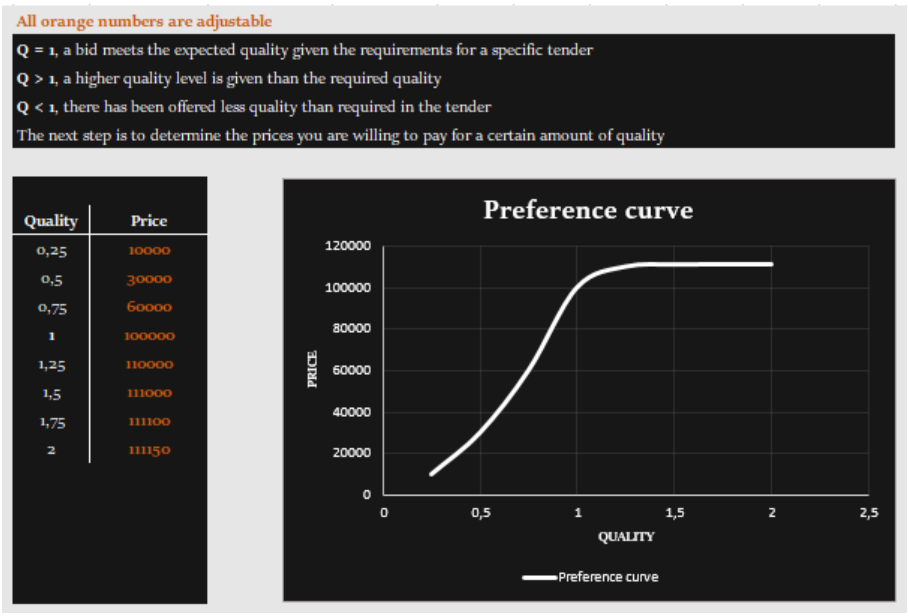


***Figure 19**: The preference curve based on the willingness of a buyer to pay for a certain amount of quality*

After the development of the preference curve, it is important to determine parameters in order to be able to compare the different award mechanism to each other. This will be done based on the following questions:

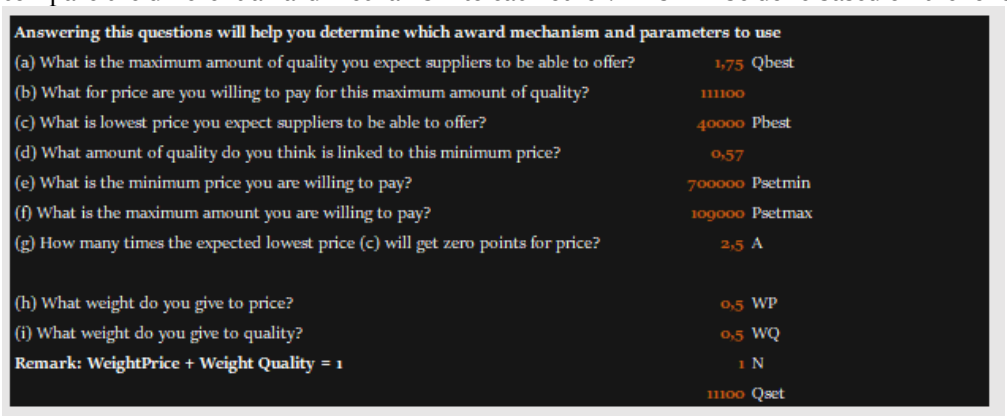


***Figure 20:** Questions which helps to get to the parameters of the different award mechanisms*

Now that the parameters are determined, the outcomes of the different award mechanisms will be calculated. This will be done based on three random offers, which are adjustable by the buyer. This resulted the following results using all data within this example:

Offer	A	B	C
Quality	0,8	1,1	1,3
Price	900000	1001000	1100010

Scores

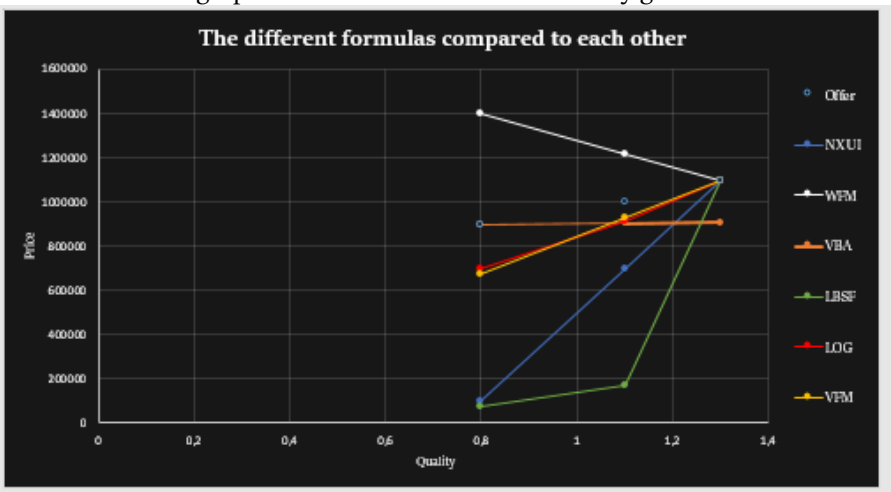
Offer	A	B	C
NX UI	0,00	0,01	0,02
WFM	1,07	1,30	1,49
VBA	891120,00	988790,00	1085580,00
LBSF	0,42	0,57	0,67
LOG	-0,80	-0,71	-0,66
VFM	0,00	0,00	0,00
ROS	0,80	1,10	1,30

Ranking

Offer	A	B	C
NX UI	3	2	1
WFM	3	2	1
VBA	1	2	3
LBSF	3	2	1
LOG	3	2	1
VFM	3	2	1
ROS	3	2	1

***Figure 21**: Outcomes of one specific example, based on the determined parameters of Figure 20.*

The next step will be the development of graphical lines to show the differences between the different award mechanisms. The graphs will be based on all data already given. This results in the following graph:



Remark: Rank on scores in survey is not processed into the graph since it does not contain profound calculations.

***Figure 22**: The different award mechanisms compared graphically*

The final step will be comparing the preference curve to the different award mechanisms. It is advised to choose one of the award mechanisms that looks rather similar to the preference curve. So fulfilling all steps mentioned above will help to choose one of the award mechanisms or at least eliminate award mechanisms that do not fit the situation. All these steps are processed in an Excel file called *Method determination based on preference curve.xlsx*.

The final type of support is the ability to let buyers play with the award mechanisms and try different parameters. Therefore, an Excel file has been created. This Excel file simulates the outcomes of different offers and give the buyer opportunity to change the data given within the file to make it realistic for their own case. It should be noted, however, that there is a disadvantage of a maximum of 26 offers that the buyer is able to fill in. So when a buyer has 30 offers in real life, it is not possible to simulate them all. Nevertheless, this does not have to be a problem since the buyer needs to determine the chosen award mechanism in advance (not knowing how much offers he will receive). Some screenshots of the Excel file can be found in *Appendix VII: Support in Excel.* The Excel itself is called *Calculations of different award mechanisms.xlsx*.

7. Conclusion and discussion

Conclusion

The aim of this research is to get an answer to the research question: *How to support buyers of Negometrix in making their decision between different award mechanisms implemented in the platform?*

First of all, all characteristics of the different award mechanisms will be summarized below.

Award mechanism	***Form***	***Absolute vs Relative***	***P+Q vs P/Q***	***Parameters***
NX Utility Index	Straight – going to a single point	Quality-relative	P / Q	- P/Q ratio - Weights to questions
Weighted Factor Method	Straight - parallel	Absolute	P + Q	- P/Q ratio - Weights to questions - Max. and min. prices
Value Based Awarding	Straight - parallel	Absolute	P based on Q	- Weights to questions in a monetary amount
Low Bid Scoring Formula	Concave up	Price-relative	P + Q	- P/Q ratio - Weights to questions
Log formula	Concave up	Price-relative*	P + Q	- P/Q ratio - Score where price receives zero points - Weights to questions
Value for money 50/50 index	Straight – going up to a single point	Absolute	P / Q	- P/Q ratio - multiplier - Weights to questions
Rank on scores in survey	Straight – parallel	Quality-relative	Q	- Weights to questions - Price score into one of the questions of the survey

* Although the formula is price-relative, the use of a log avoids the possibility of ranking reversal.

Secondly, interviews showed that buyers required at least some graphical support. However, buyers also thought that it would be even better if there would be a combination of graphical support, calculations and explanations. Therefore, three different kinds of support have been developed to support buyers of Negometrix in making their decision between the different award mechanisms implemented in the platform:

1. Decision trees: eliminates award mechanisms that do not fit within a particular situation based on a subject chosen by the buyer.
2. Preference curve: a buyer need to determine its own preference curve and compare it to the different award mechanisms to check which award mechanisms looks similar to the preference curve.
3. Simulation model: gives the ability to buyers to play with the award mechanisms and its parameters. The simulation is based on a maximum of 26 offers and is adjustable to make it more case specific.

The best way to support buyers is to use one of the developed support models or combine the different kinds of support in order to choose an award mechanism.

Discussion

This thesis has made a good start towards supporting buyers in making their decision between different award mechanism. It contains useful information about the different award mechanisms implemented in the Negometrix platform. Additionally, some support has been developed which helps buyer to eliminate irrelevant award mechanism and gives a clear direction towards the final step of choosing an award mechanism. Although this thesis is a good start towards the development of full support for buyers, there are definitely opportunities for expansion and improvement.

First of all, future research may focus on other award mechanisms as well. As a result, the support system will be usable by anyone and is not only restricted to buyers using the Negometrix platform. It is possible to use the developed support for cases outside the platform of Negometrix, however, this will not ensure buyers outside the platform are fully supported due to the absence of other award mechanisms.

Another main aspect that should get focus in future research is the presence of parameters. This thesis is mainly focusing on being able to choose an award mechanism, but does not give in-depth information about the different parameters involved. So the support may be improved when buyers will be supported in determining the parameters as well. One way to do this is by estimating the parameters based on preference curves.

Additionally, improvement of support will take place when there is a final assessment of the support system by buyers. This will give insight on the desires of buyers and it also shows the advantages as well as the disadvantages that follow from the developed support within this thesis. Another improvement considering buyers will be the number of interviews that will take place in future research. This research only contained five in-depth interviews, but in order to get a more realistic view it may be better to interview additional buyers. Therefore, it is suggested to involve more customers into the process and take their opinions into account to improve the current support system.

Altogether, this thesis makes a good start towards fully supporting buyers in their decision between the different award mechanisms, but it still takes some time and research to offer general support to all buyers worldwide.

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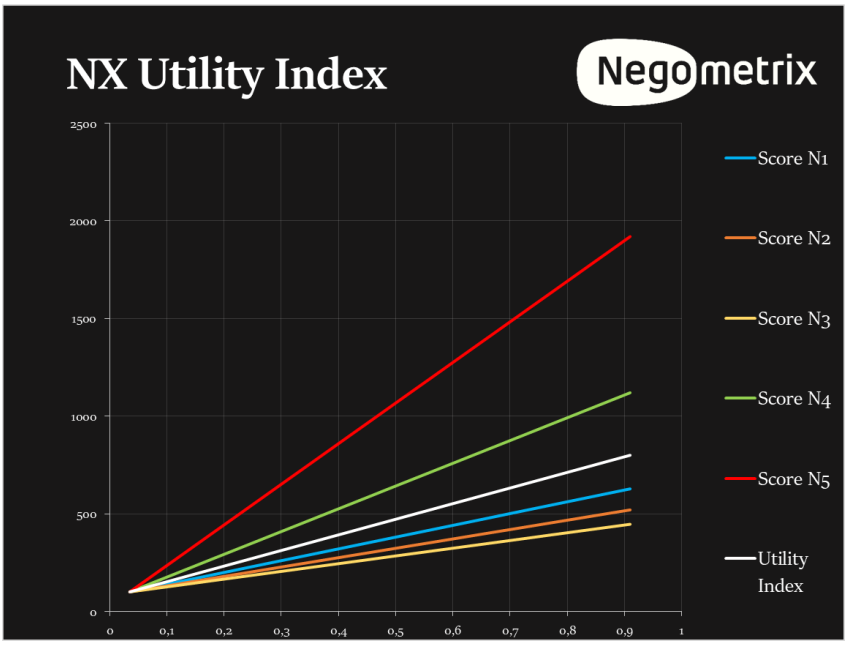
9. Appendices

Appendix I: What happens when changing the parameters?

All examples are based on twenty six offers, which are described in front of the used formula. It should be noted that all examples contain the change of only one parameter. Thus, award mechanisms that consist of multiple parameters will be mentioned more often. Therefore, the influence of changing a specific parameter can be seen. According to Albano (2014, is a characteristic of steeper award mechanisms that they imply fiercer competition.

Finally, The award mechanisms value for money 50/50 index and rank on scores in survey do not have influencing parameters that need to be determined by buyers. Therefore, they will not be taken into account in this chapter.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



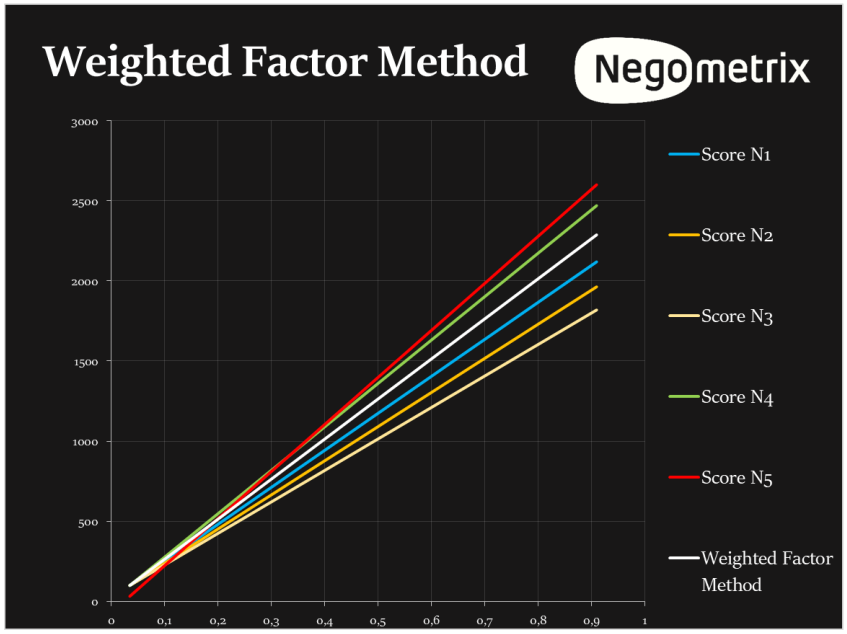
WeightP	0,5	**N UI**	**1**
WeightQ	0,5	N=WeightQ/ WeightP	

Seeing the effect of changing the price/quality ratio:

WeightP1	0,51	**Score N1**	0,96078
WeightQ1	0,49	**Score N2**	0,923077
WeightP2	0,52	**Score N3**	0,886792
WeightQ2	0,48	**Score N4**	1,040816
WeightP3	0,53	**Score N5**	1,083333
WeightQ3	0,47		
WeightP4	0,49		
WeightQ4	0,51		
WeightP5	0,48		
WeightQ5	0,52		

As one can see, the higher the quality/price ratio, the steeper the NX UI line. This means, there will be fiercer competition when the weight of quality has been increased.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



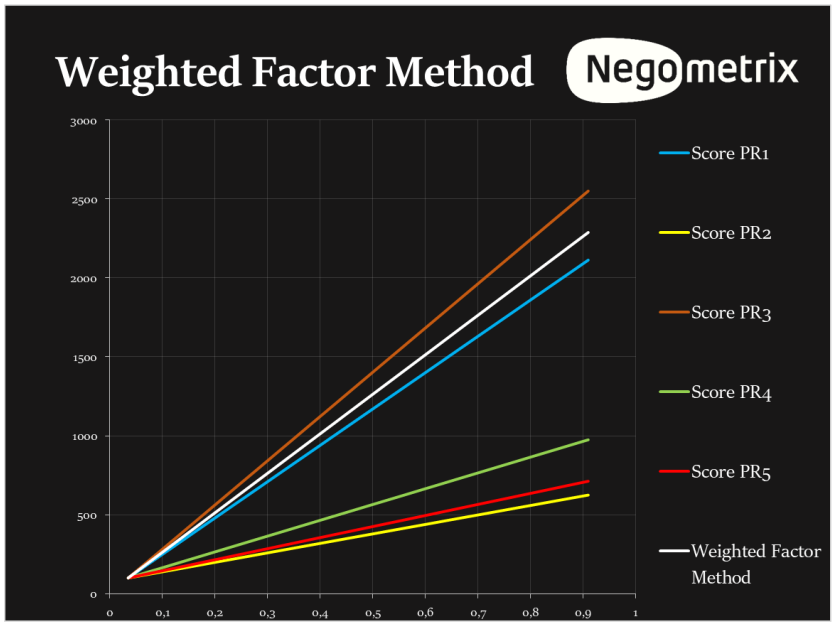
WeightP	**0,5**
WeightQ	**0,5**

Seeing the effect of changing the price/quality ratio:

Score N1: **WeightP1**	0,52
Score N1: **WeightQ1**	0,48
Score N2: **WeightP2**	0,54
Score N2: **WeightQ2**	0,46
Score N3: **WeightP3**	0,56
Score N3: **WeightQ3**	0,44
Score N4: **WeightP4**	0,48
Score N4: **WeightQ4**	0,52
Score N5: **WeightP5**	0,46
Score N5: **WeightQ5**	0,54

As one can see, the higher the quality/price ratio, the steeper the WFM line. This means, there will be fiercer competition when the weight of quality has been increased. Yet, this parameter has less influence than in the NX Utility Index.
Note: All other parameters did not change during the calculations for this example.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



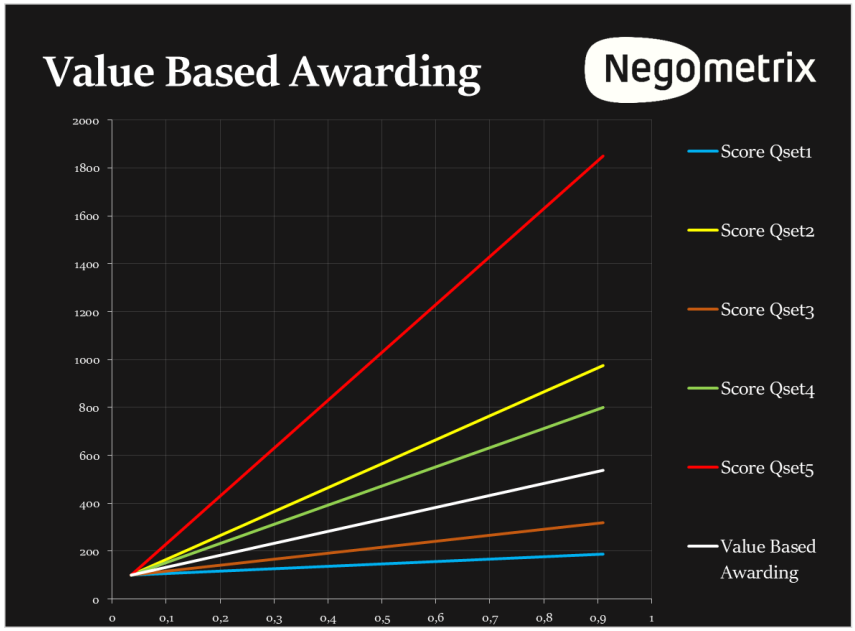
Psetmin	**100**
Psetmax	**2600**

Seeing the effect of changing the price range:

Score PR1: **Psetmin1**	200
Score PR1: **Psetmax1**	2500
Score PR2: **Psetmin2**	600
Score PR2: **Psetmax2**	1200
Score PR3: **Psetmin3**	200
Score PR3: **Psetmax3**	3000
Score PR4: **Psetmin4**	1000
Score PR4: **Psetmax4**	2000
Score PR5: **Psetmin 5**	1500
Score PR5: **Psetmax 5**	2200

As one can see, the broader the range between Psetmin and Psetmax, the steeper the WFM line. This means, you allow suppliers more freedom with a broader range. It should be noted, however, that combinations having the same range will result in the same line (e.g., 100-2600 and 200-2700).
Note: All other parameters did not change during the calculations for this example.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



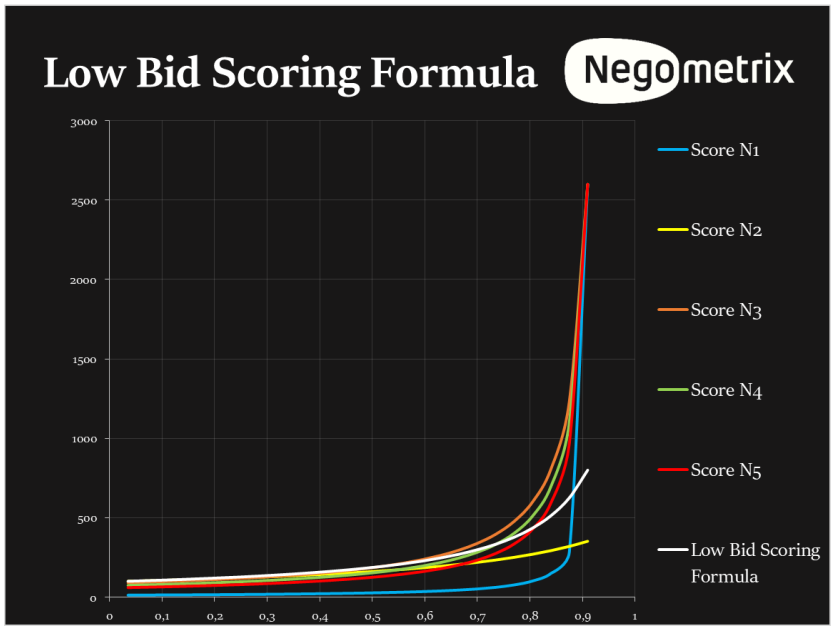
Qset VBA	**500**

Seeing the effect of changing Qset:

Score Qset1	100
Score Qset2	1000
Score Qset3	250
Score Qset4	800
Score Qset5	2000

As one can see, the higher the Qset, the steeper the VBA line. This means, there will be fiercer competition when the Qset has been increased. However, it is of relevance that Qset is based on realistic numbers derived from the real word.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



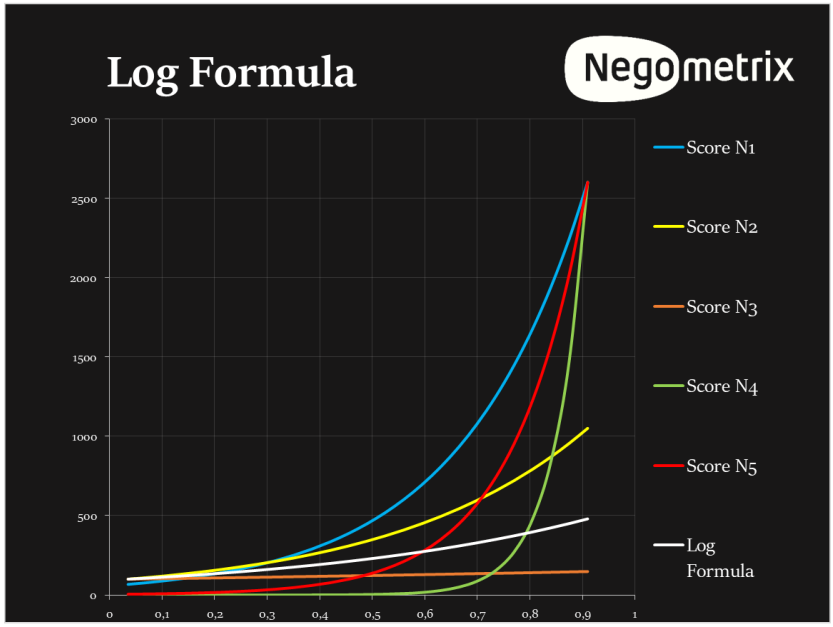
LBSF WeightP	**0,5**
LBSF WeightQ	**0,5**

Seeing the effect of changing the price/quality ratio:

Score N1: **WeightP1**	0,6
Score N1: **WeightQ1**	0,4
Score N2: **WeightP2**	0,55
Score N2: **WeightQ2**	0,45
Score N3: **WeightP3**	0,45
Score N3: **WeightQ3**	0,55
Score N4: **WeightP4**	0,4
Score N4: **WeightQ4**	0,6
Score N5: **WeightP5**	0,35
Score N5: **WeightQ5**	0,65

As one can see, the higher the weight of price, the more horizontal the LBSF line and the higher the weight of quality, the more curved the LBSF line. So changes of weights do influence the determination of the formation of the graph.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



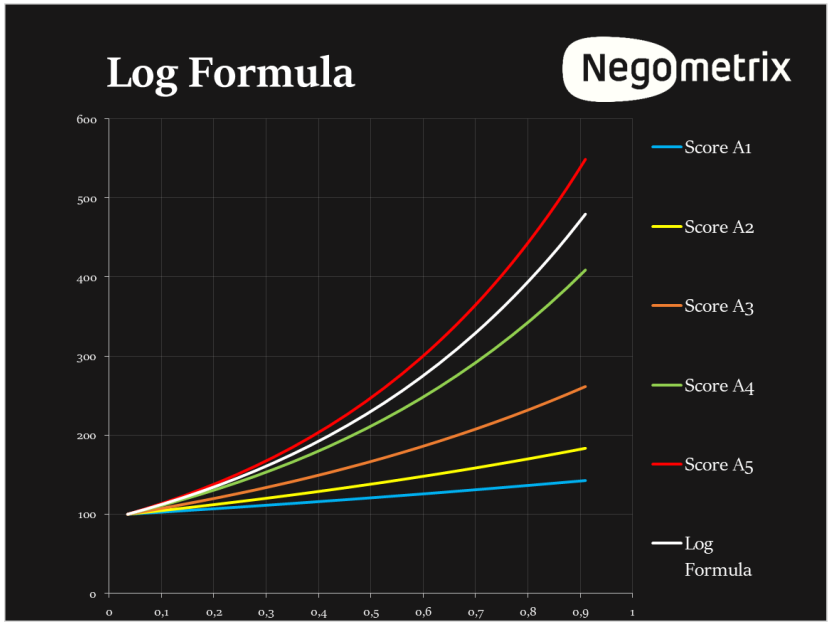
WeightP LOG	**0,5**
WeightQ LOG	**0,5**

Seeing the effect of changing the price/quality ratio:

Score N1: **WeightP1**	0,3
Score N1: **WeightQ1**	0,7
Score N2: **WeightP2**	0,4
Score N2: **WeightQ2**	0,6
Score N3: **WeightP3**	0,8
Score N3: **WeightQ3**	0,2
Score N4: **WeightP4**	0,1
Score N4: **WeightQ4**	0,9
Score N5: **WeightP5**	0,2
Score N5: **WeightQ5**	0,8

As one can see, the higher the weight of price, the more horizontal the LBSF line and the higher the weight of quality, the more curved the LBSF line. Comparing this to the LBSF shows that changing the weights does have the same influence to the graph.
Note: All other parameters did not change during the calculations for this example.

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600



A LOG	**6**

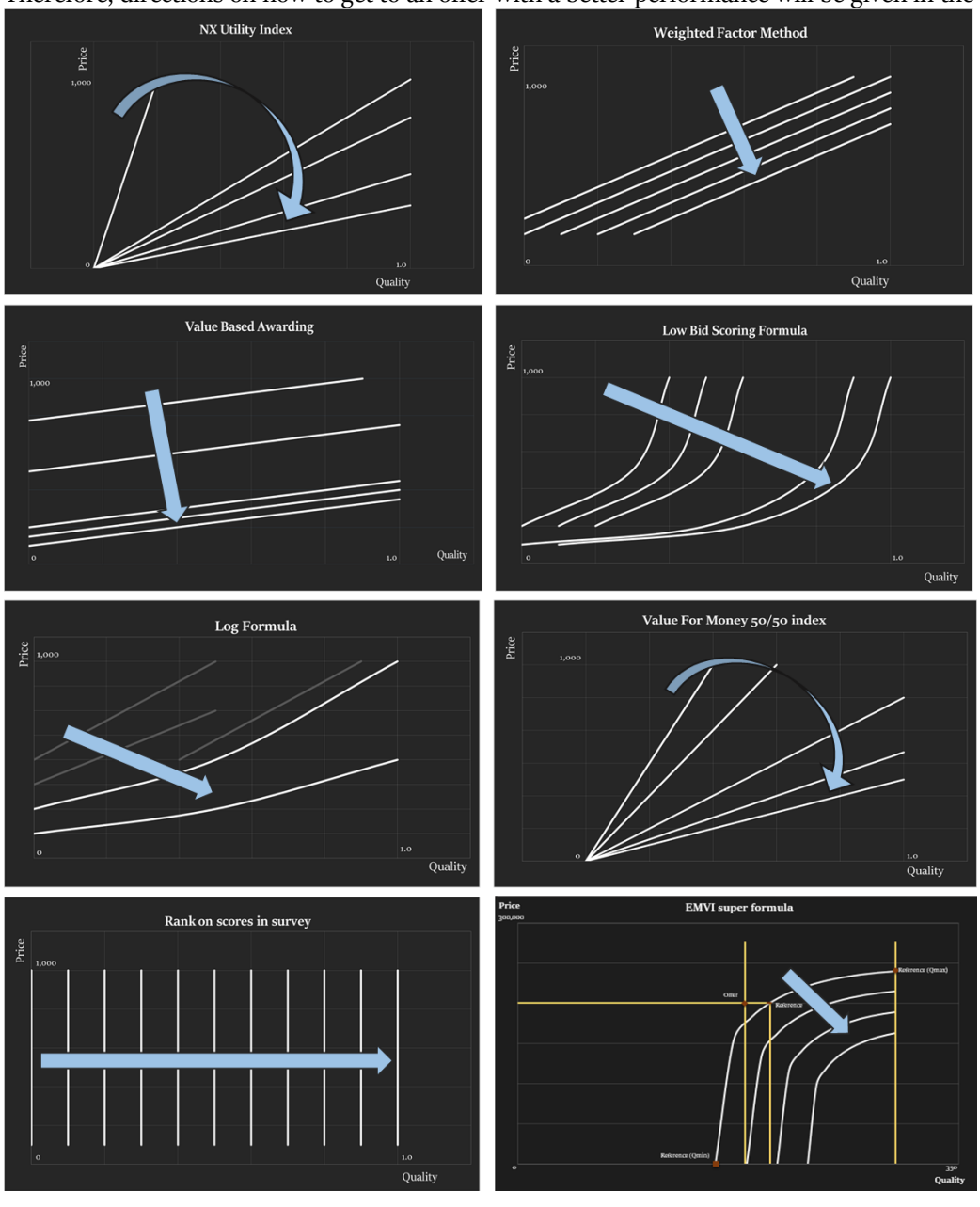
Seeing the effect of changing A:

Score A1	1,5
Score A2	2
Score A3	3
Score A4	5
Score A5	7

As one can see, the higher the A, the steeper the curved line. An A that is approaching zero is causing an horizontal line, which results in the absence of a clear outcome. An smaller A, however, is giving price more influence on the total score.
Note: All other parameters did not change during the calculations for this example.

Appendix II: How to get to the best score?

First of all, it is important to know which offer will be chosen when a certain award mechanism is used. Therefore, directions on how to get to an offer with a better performance will be given in the figure below.



Appendix III: All intermediate steps in rewriting formulas

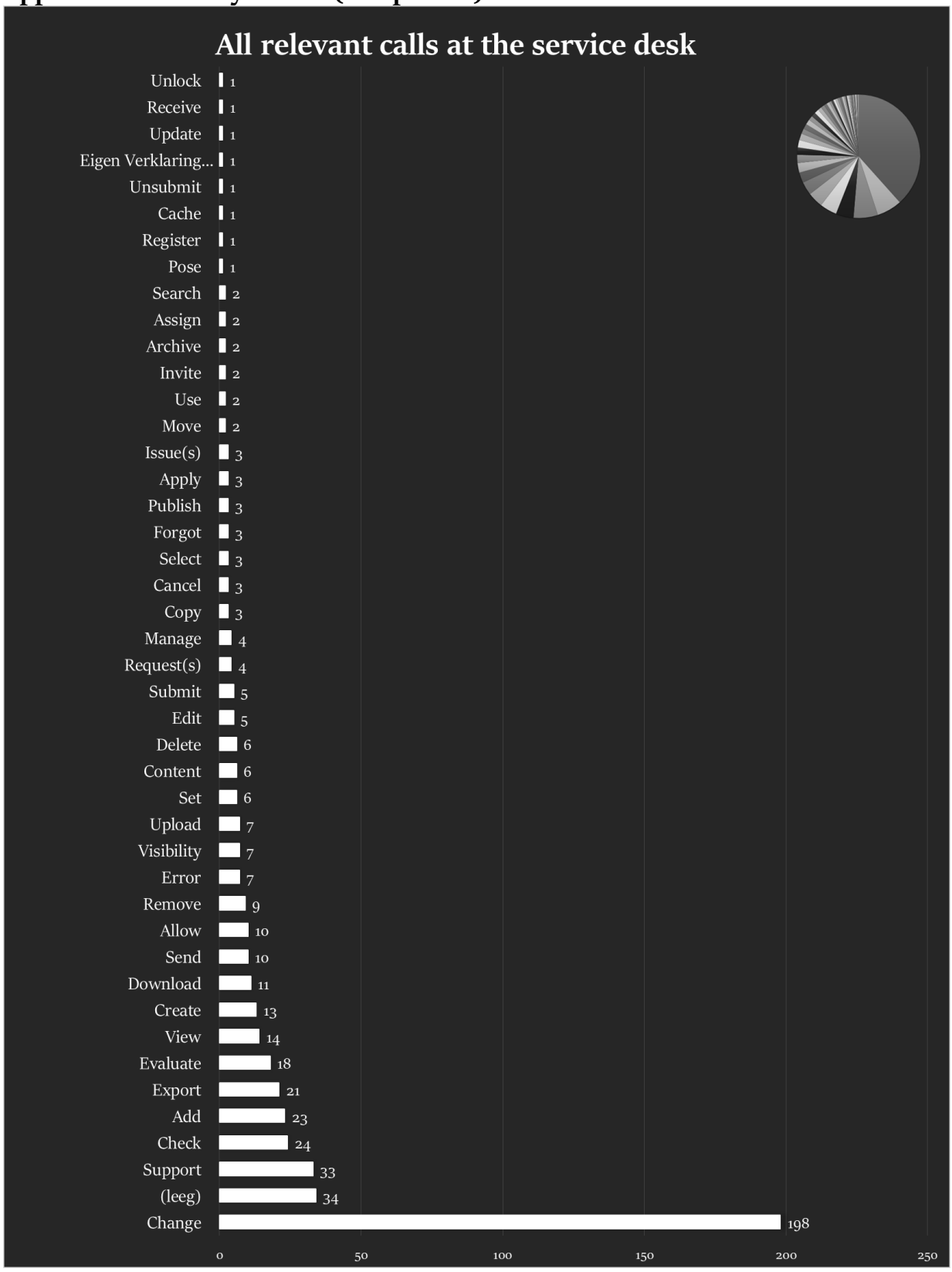
NX Utility Index:

$$u = \frac{(1-(Q_{best}-Q_i)*N)}{P_i} * P_{best} = \frac{\left(1-(Q_{best}-Q_i)*\frac{WQ}{WP}\right)}{P_i} * P_{best} = \frac{(WP - WQ(Q_{best}-Q_i))}{WP * P_i} * P_{best} = \frac{WP * Pbest}{WP*Pi} - \frac{(WQ(Q_{best}-Q_i))}{WP * P_i} * P_{best} = \frac{Pbest}{Pi} - \frac{WQ*(Qbest-Qi)}{WP*Pi} * Pbest$$

Log Formula:

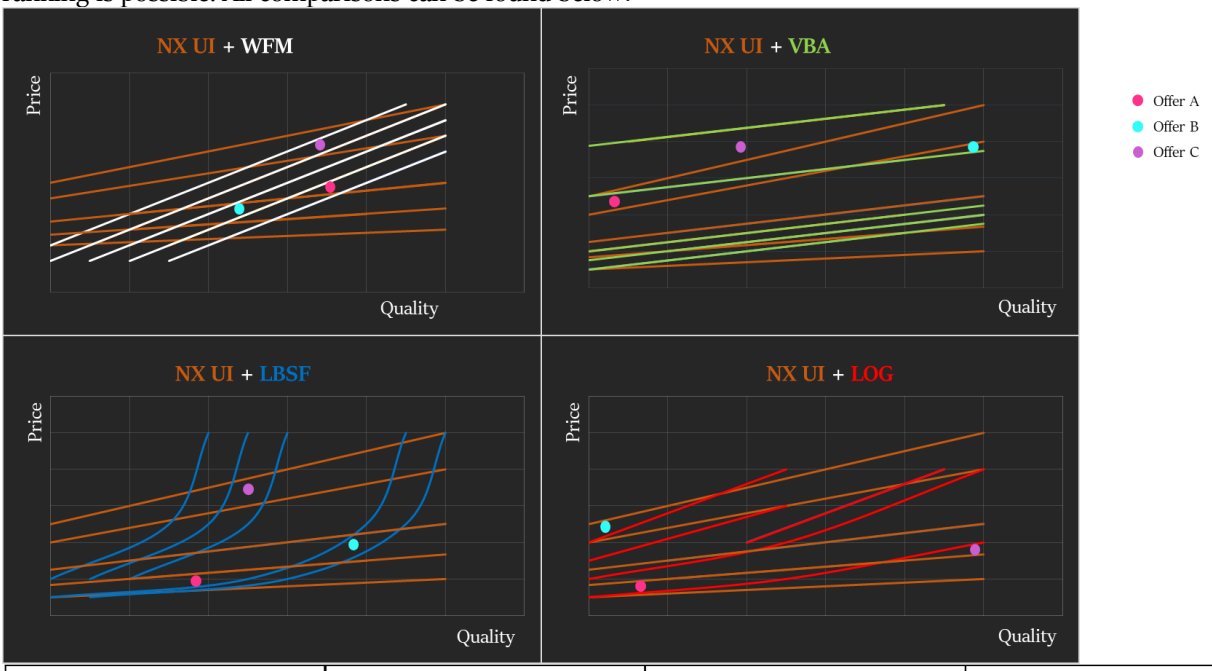
$$log = WQ * Q_i + WP\left(1 - \frac{\log\left(\frac{P_i}{P_{best}}\right)}{\log(A)}\right) = WQ * Qi + WP\left(1 - \frac{\log(Pi) - \log(Pbest)}{\log(A)}\right) = WQ * Qi + WP - WP(\frac{\log(Pi) - \log(Pbest)}{\log(A)})$$

Appendix IV: All buyer calls (complaints) considered to be relevant



Appendix V: Another award mechanism may change the ranking

All graphs of the award mechanisms are compared to each other in order to check whether different award mechanisms result in different rankings. Notably, each comparison show that differences between the ranking is possible. All comparisons can be found below:

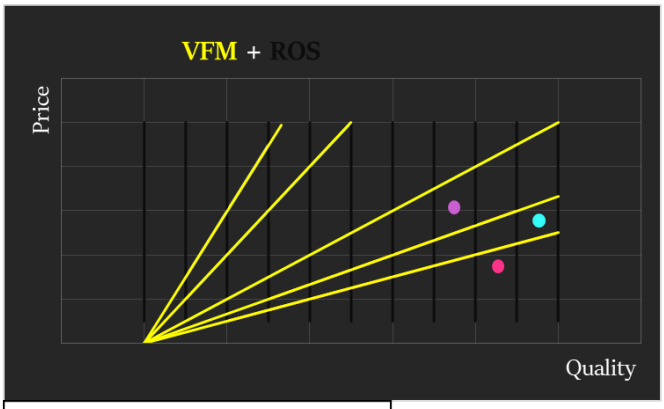


Ranking NX UI + WFM			
NX UI		WFM	
Offer A	2	Offer A	1
Offer B	1	Offer B	2
Offer C	3	Offer C	3

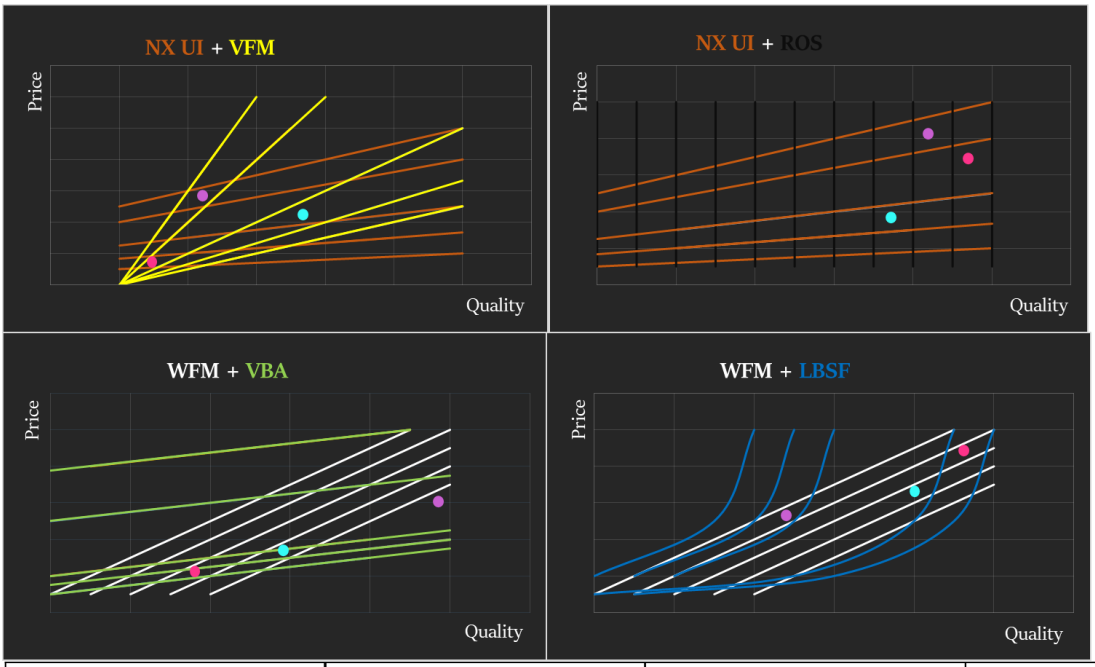
Ranking NX UI + VBA			
NX UI		VBA	
Offer A	2	Offer A	1
Offer B	1	Offer B	2
Offer C	3	Offer C	3

Ranking NX UI + LBSF			
NX UI		LBSF	
Offer A	1	Offer A	2
Offer B	2	Offer B	1
Offer C	3	Offer C	3

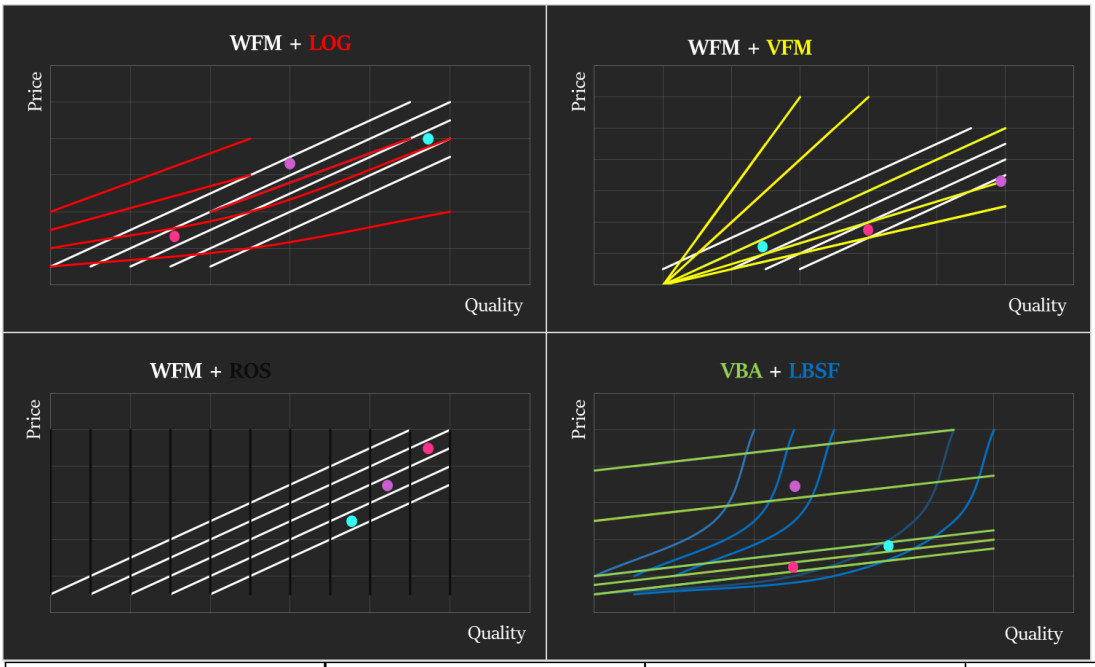
Ranking NX UI + LOG			
NX UI		LOG	
Offer A	1	Offer A	2
Offer B	3	Offer B	3
Offer C	2	Offer C	1



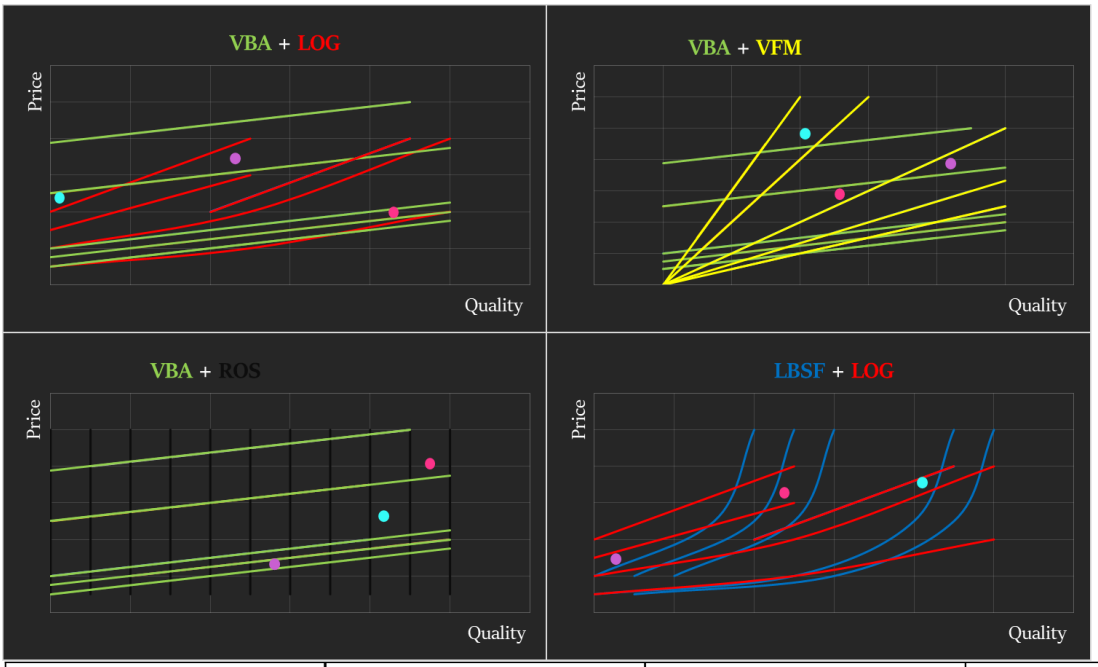
Ranking VFM + ROS			
VFM		ROS	
Offer A	1	Offer A	2
Offer B	2	Offer B	1
Offer C	3	Offer C	3



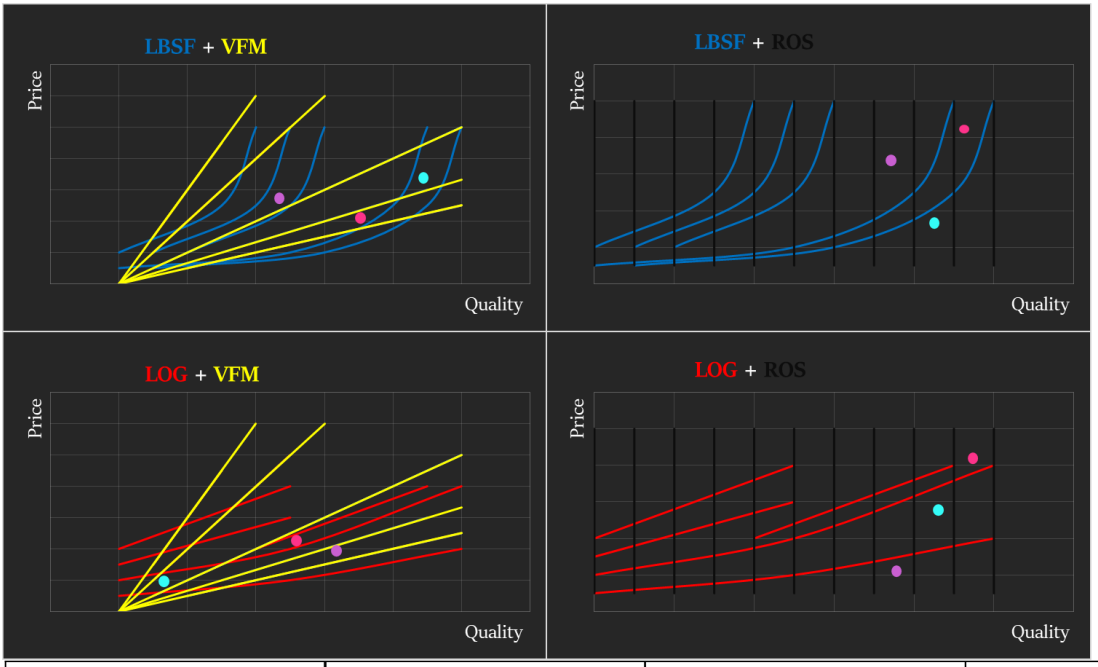
Ranking NX UI + VFM				Ranking NX UI + ROS				Ranking WFM + VBA				Ranking WFM + LBSF			
NX UI		VFM		NX UI		ROS		WFM		VBA		WFM		LBSF	
Offer A	1	Offer A	2	Offer A	2	Offer A	1	Offer A	3	Offer A	1	Offer A	2	Offer A	1
Offer B	2	Offer B	1	Offer B	1	Offer B	3	Offer B	2	Offer B	2	Offer B	1	Offer B	2
Offer C	3	Offer C	3	Offer C	3	Offer C	2	Offer C	1	Offer C	3	Offer C	3	Offer C	3



Ranking WFM + LOG				Ranking WFM + VFM				Ranking WFM + ROS				Ranking VBA + LBSF			
WFM		LOG		WFM		VFM		WFM		ROS		VBA		LBSF	
Offer A	2	Offer A	1	Offer A	2	Offer A	1	Offer A	3	Offer A	2	Offer A	1	Offer A	2
Offer B	1	Offer B	2	Offer B	3	Offer B	3	Offer B	1	Offer B	3	Offer B	2	Offer B	1
Offer C	3	Offer C	3	Offer C	1	Offer C	2	Offer C	2	Offer C	2	Offer C	3	Offer C	3



Ranking VBA + LOG				Ranking VBA + VFM				Ranking VBA + ROS				Ranking LBSF + LOG			
VBA		LOG		VBA		VFM		VBA		ROS		LBSF		LOG	
Offer A	1	Offer A	1	Offer A	1	Offer A	2	Offer A	3	Offer A	1	Offer A	2	Offer A	3
Offer B	2	Offer B	3	Offer B	3	Offer B	3	Offer B	2	Offer B	2	Offer B	1	Offer B	1
Offer C	3	Offer C	2	Offer C	2	Offer C	1	Offer C	1	Offer C	3	Offer C	3	Offer C	2



Ranking LBSF + VFM				Ranking LBSF + ROS				Ranking LOG + VFM				Ranking LOG + ROS			
LBSF		VFM		LBSF		ROS		LOG		VFM		LOG		ROS	
Offer A	2	Offer A	1	Offer A	2	Offer A	1	Offer A	3	Offer A	2	Offer A	3	Offer A	1
Offer B	1	Offer B	2	Offer B	1	Offer B	2	Offer B	1	Offer B	3	Offer B	2	Offer B	2
Offer C	3	Offer C	3	Offer C	3	Offer C	3	Offer C	2	Offer C	1	Offer C	1	Offer C	3

Appendix VI: Support in Excel

The first award mechanism processed in Excel is the NX Utility Index. The sheet can be found below:

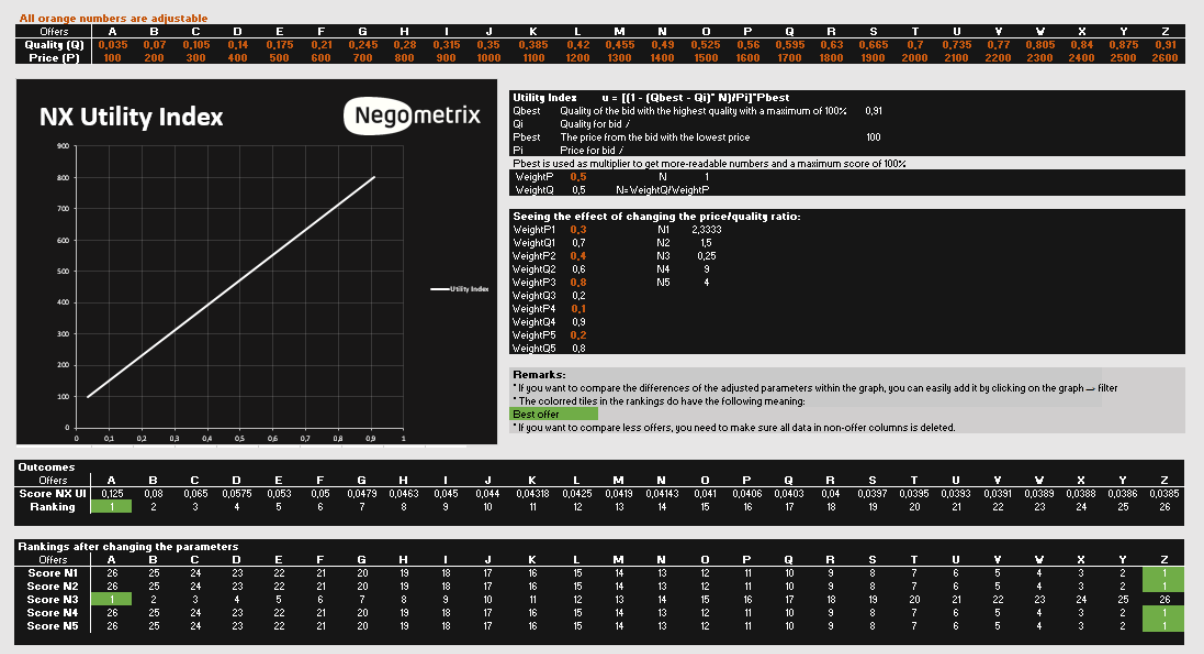


Figure 23: *Support sheet for the NX Utility Index*

Some explanation is given on the different award mechanisms, such as the meaning of the parameters. Additionally, some remarks are given that should be taken into account while using the Excel file:

- If you want to compare the differences of the adjusted parameters within the graph, you can easily add it by clicking on the graph → filter
- The coloured tiles in the rankings do have the following meaning: Best offer
- If you want to compare less offers, you need to make sure all data in non-offer columns is deleted.

The scores and their corresponding ranking can be found on the bottom of the sheet. Buyers are able to adjust all orange numbers in order to make it more realistic for their own case. At the top of the sheet, buyers may adjust the different offers. On the right, buyers may adjust the parameters. Additional parameters are shown below and are also adjustable in order to check the differences by changing the parameters. To be able to compare differences in the parameter, different scores can easily be added through a filter (this holds for all award mechanisms):

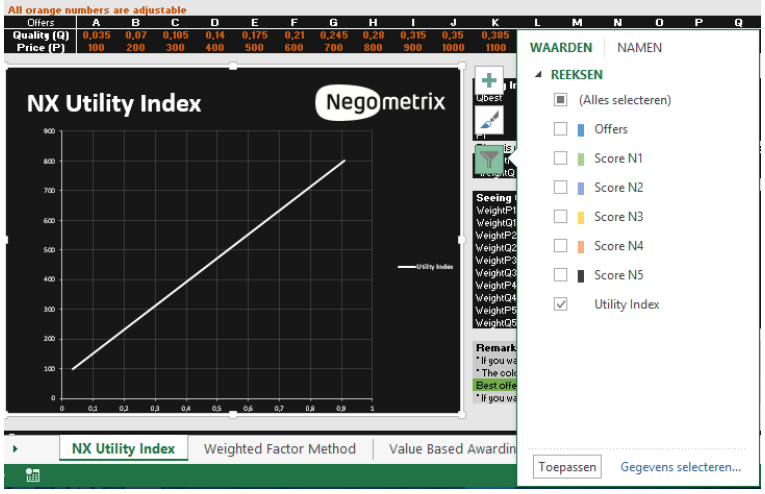


Figure 24*: Filter to add or remove scores based on adjusted parameters*

The operating mode of the sheets are the same for every award mechanism. Therefore, only screenshots of the remaining award mechanisms will be given below:

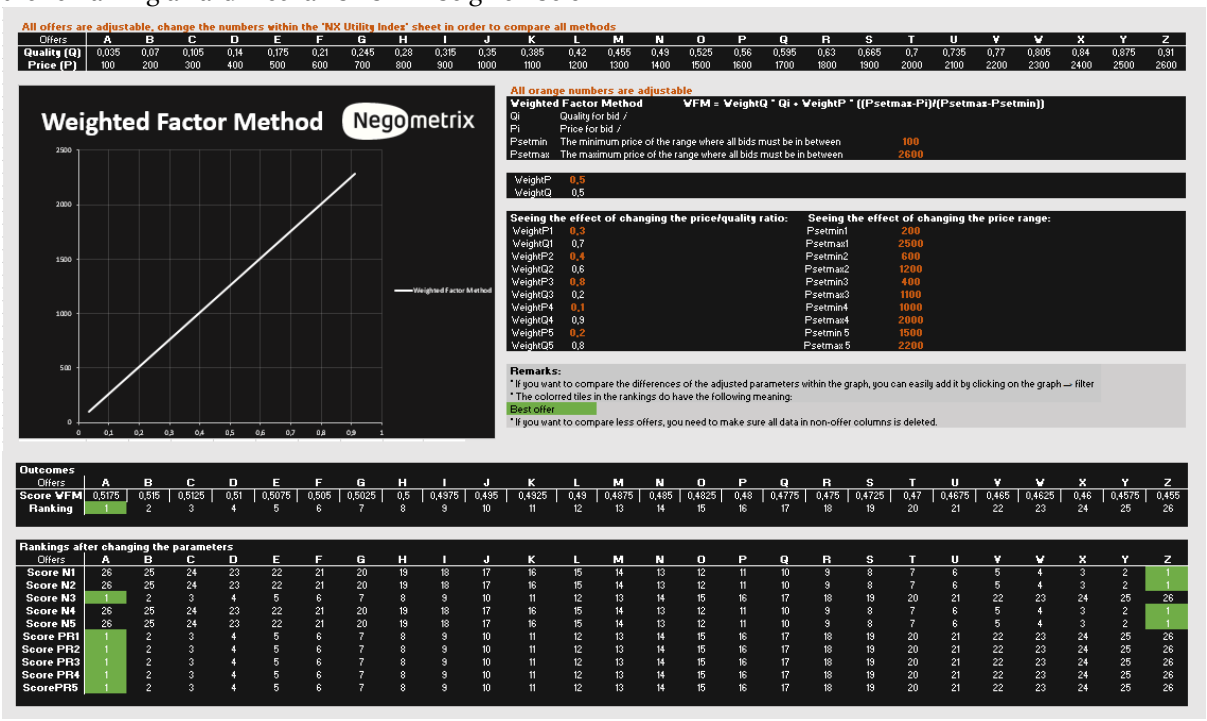


***Figure 25**: Support sheet for the Weighted Factor Method*

It should be noted, however, that comparing the different parameters is only based on changing one parameter at a time. So there is no option to compare the scores of changing two parameters at the same time. This does hold for all award mechanisms that have more than one parameter to define.

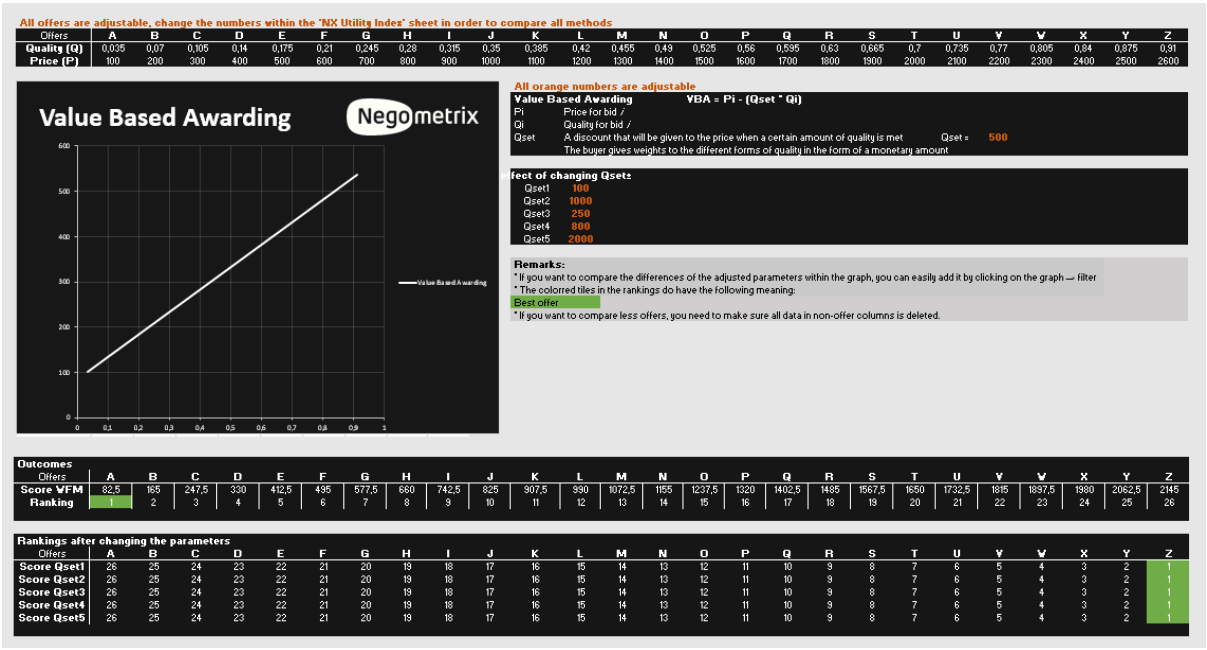


***Figure 26**: Support sheet for Value Based Awarding*

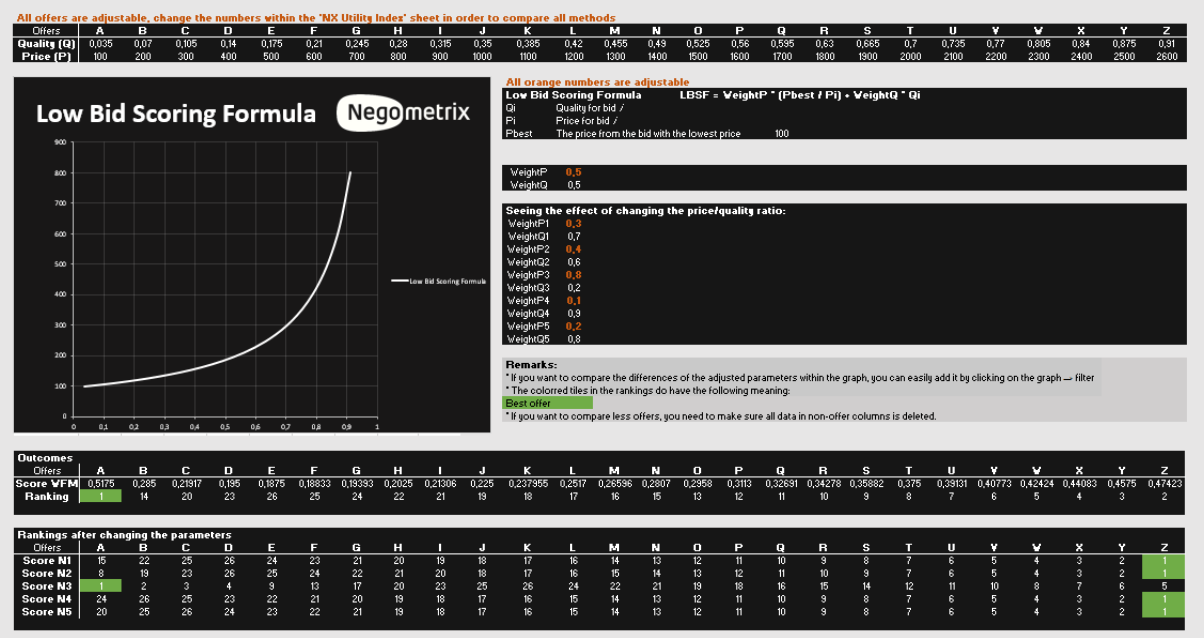


***Figure 27**: Support sheet for the Low Bid Scoring Formula*

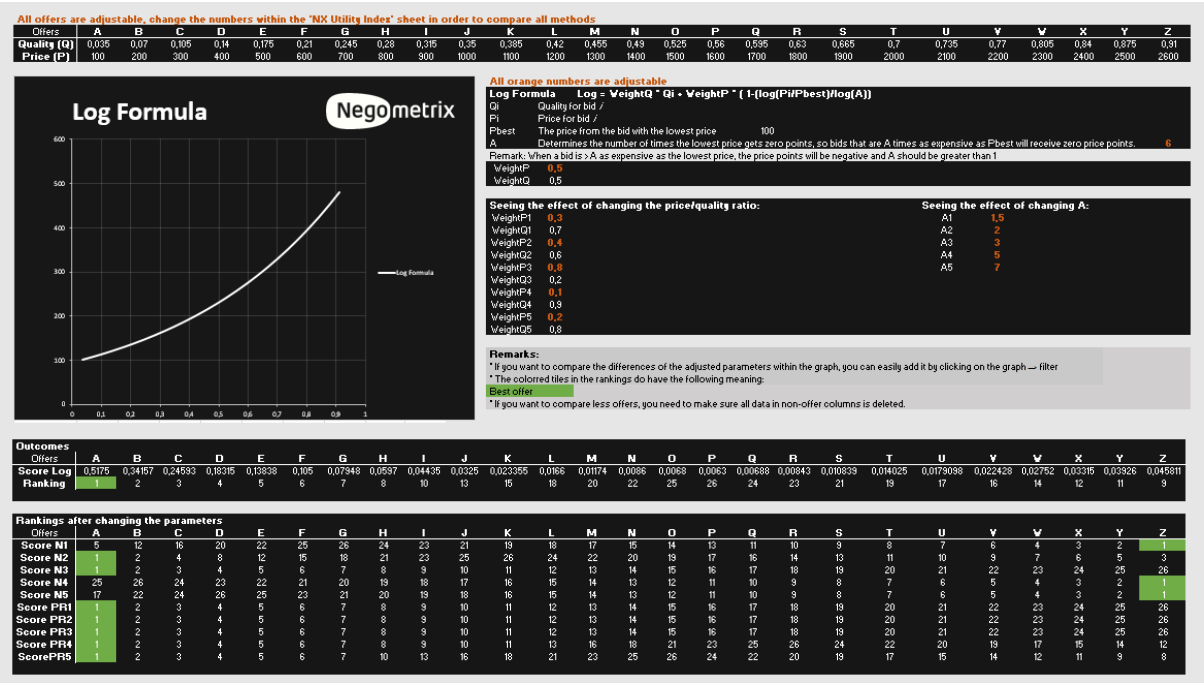


***Figure 28**: Support sheet for the log formula*

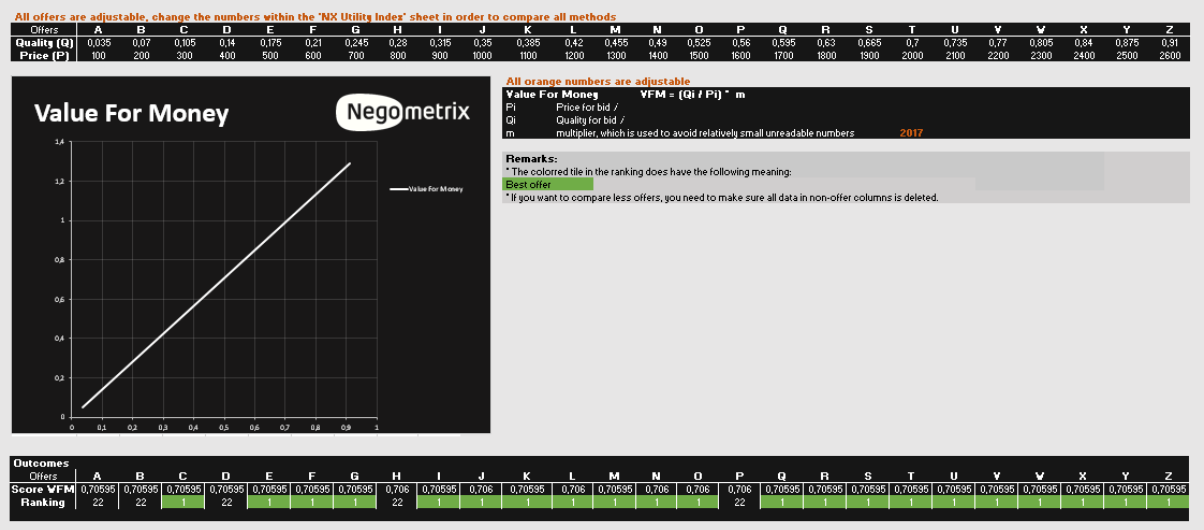


***Figure 29**: Support sheet for the value for money 50/50 index*

After dealing with all award mechanism separately, one sheet is added to compare the different award mechanisms. This sheet can be found below:

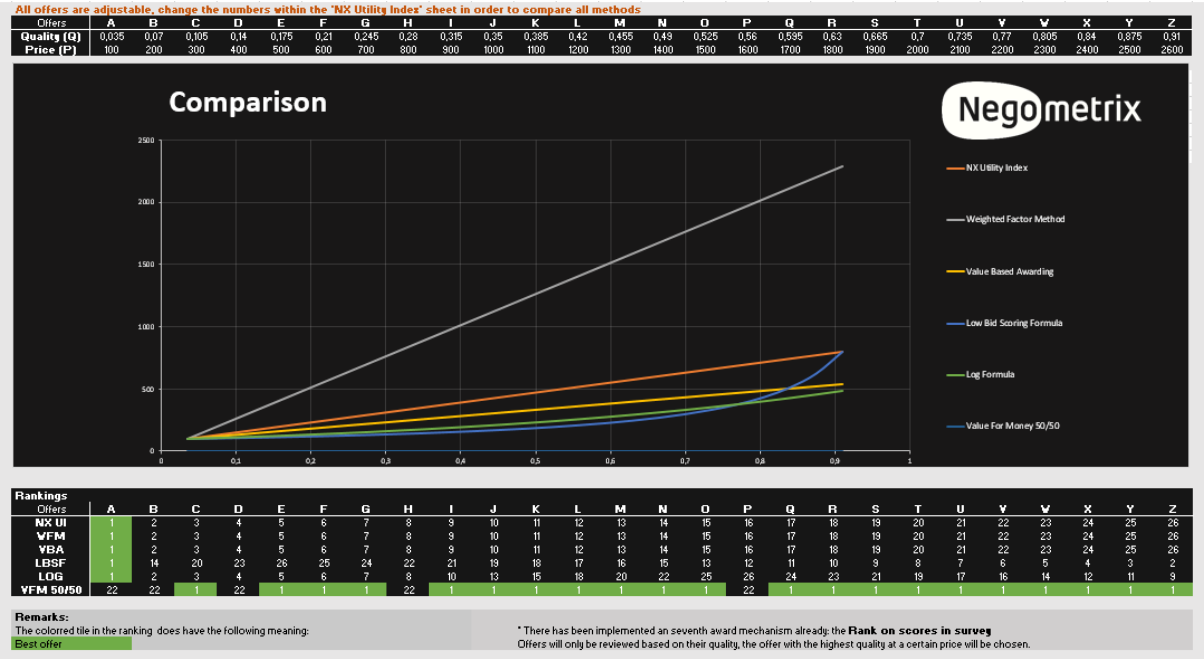


***Figure 30**: Support sheet for comparing the different award mechanisms*

The sheets are based on the following offers:

Offers	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Quality (Q)	0,035	0,07	0,105	0,14	0,175	0,21	0,245	0,28	0,315	0,35	0,385	0,42	0,455	0,49	0,525	0,56	0,595	0,63	0,665	0,7	0,735	0,77	0,805	0,84	0,875	0,91
Price (P)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600

However, changing the offers result in quite different results. Therefore, it should be taken into account that it concerns an example of the different award mechanisms. This may cause parameters to have a bigger influence on the ranking.

Finally, it must be mentioned that the rank on scores in survey is not part of the Excel file. This is due to the fact that it does not contain real calculations and is therefore not comparable with the calculations of other award mechanisms. However, this does not mean that there is no opportunity to use the rank on scores in survey method.