How to win a tender

The development of a support system for suppliers to choose their most promising bid.

A bachelor thesis

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Author
I. Schepers
Student number: 1589822
Education: Industrial Engineering & Management

Supervisors
Prof. dr. J. Telgen (University of Twente)
Dr. Ir. F. Schotanus (University of Twente)
J. Siderius (Negometrix)

Negometrix

UNIVERSITY OF TWENTE.

Preface

The report that is before you is the result of my internship at Negometrix on completion of the bachelor Industrial Engineering and Management at the University of Twente. I researched how to develop a support system for suppliers to help them to optimise their bid. This research is conducted at Negometrix in Utrecht, the Netherlands. After extensive research, I was able to answer my research questions and develop a support system for suppliers making it is easier for suppliers to make the decision which bid is most promising.

I would like to thank my supervisor, Jan Siderius, at the company Negometrix for providing me the opportunity to work at Negometrix and use the data in their system. Data such as: which suppliers are using the software, what kind of complaints the suppliers have and how the bids that suppliers provide look like. Also, I would like to thank the suppliers who participated in the interviews I conducted for my research.

Furthermore, I would like to thank my supervisors from the University of Twente, Jan Telgen and Fredo Schotanus, for supporting me and providing me with advice and knowledge. Without their collaboration I was never able to complete my research.

I hope you find this report enjoyable and informative.

Ilse Schepers
Enschede, the Netherlands
21-08-2018

Management Summary

Research motivation

Negometrix is an electronic platform where buyers can carry out a tender and enable the suppliers to provide a bid. Buyers make the decision to carry out a tender with the software of Negometrix. Suppliers, on the other hand, are more or less obliged to work with the software of Negometrix. That is why Negometrix wants a good support system; to make it easy for suppliers to work with the software and award mechanisms. The goal of this research assignment is to design an improved support system for suppliers that help them to make a choice which bid they should provide.

For Negometrix it is important to support suppliers in this process. Putting forward a better score will also be positive for the buyer, because they get offers with the highest scores possible. Also it can improve the economic situation in terms of competition for Negometrix. The support system that needs to be developed for suppliers can also be used by companies other than Negometrix. Therefore, the general usability and utility increases by means of the development of the support system.

Research goal

The goal of this research is to design a support system that Negometrix can provide to suppliers, in order to inform the supplier about the most promising bid. Upon achieving this goal the supplier can provide his most promising bid.

With this information, we have come up with the following main research question: 'How to design a support system of the various award mechanisms in a way that the supplier knows which bid will be most promising?' There are some restrictions when optimising a bid. For example, the costs incurred by the supplier. This must be taken into account.

Research design

In the first part of the research we want to create a clear view about the award mechanisms used by Negometrix, because it is important to know how the award mechanisms work to be able to develop the support system. This is done by conducting a literature review.

The analysis of the current situation embraces the second part of the research. The goal is to have a clear view about the current support provided to suppliers. We are also performing individual in-depth interviews with suppliers to get a good understanding about what they think is necessary and useful in the support system. Finally, we want to elaborate on other already existing support system for suppliers. The goal is to know which components of these existing support systems are useful for the development of our support system.

The goal of the third part of the research is to get a clear view of how the support system can be developed and what the characteristics should be. This is done by conducting a literature review about how a supplier chooses their most promising bid.

In the last part of the research we are going to develop a support system for the suppliers to provide their most promising bid. Important factors when developing the support system are: the wishes of the suppliers, the wishes of Negometrix, the interests of the customers of Negometrix and what the characteristics of the support system should be.

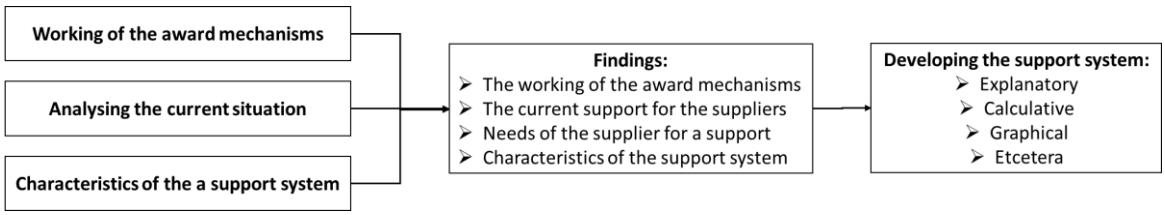

Figure 1 summary of the problem-solving approach

Results

Due to time pressure we only did research on the following award mechanisms: NX Utility index, Weighted Factor Method and Low Bid Scoring formula. Information about the various award mechanisms can be found in Chapter *3. The working of the award mechanisms*. It is important for suppliers to know the direction for better performance, because than suppliers have indications in which direction they have to look, to find the most promising bid. It is also important for suppliers to know the purpose of the different parameters in the formula and how they can influence the direction for better performance. Buyers can use various scoring methods when using the software of Negometrix: relative and absolute scoring methods. The difference is that the outcome of a relative scoring method depends often on the best price and/or best quality. The best price and best quality are difficult to determine and can only be estimated. This is important information for the development of the support system.

After the research about the various award mechanisms, we analysed the current situation, starting with research about the available support for suppliers provided by Negometrix. We come to the conclusion that they can use instruction documents about the award mechanisms and a calculation sheet of the award mechanisms, but the calculation sheet is not especially made for suppliers and there is no support for suppliers to choose their most promising bid.

The next step in analysing the current situation are five in-depth interviews that have been conducted with suppliers. The interviews show that in general, suppliers are very satisfied with the support given to them. However, they think that the software and the support of Negometrix is especially focused on buyers. Further, it is clear that small and medium enterprises (SME's) are asking for more support about award mechanisms, because SME's often have no bid managers and therefore less knowledge about award mechanisms. The main focus of suppliers to choose the most promising bid is on the weight of the quality and price. The weight of quality and price influence the direction for better performance and are important factors to be able to optimise a bid. One supplier thinks that it is sometimes difficult to determine the weight of the quality and price, because not every award mechanism is transparent. Generally, the suppliers want a good explanation of the various award mechanisms and good support to be able to compare various options. The summary of the interviews can be found in Section *4.2 What do supplier think about the support given to them?.*

The last step in analysing the current situation is to determine if there are already existing support systems for suppliers to optimise their bid. Unfortunately, we did not find any support systems for suppliers to optimise their bid, see Section *4.3 Already existing support systems for suppliers*.

Lastly, some research has been done in order to find the characteristics of the support system, see Chapter *5. How to develop a support system for suppliers to optimise their bid?*. We came to the conclusion that the support system should consist of: an explanation of the mathematical form of the award mechanisms, a graphical explanation of award mechanisms and a calculation model to calculate the score of various bids.

All the information above is used to develop the support system for suppliers to optimise their bid. The support system is made in Excel, because it is a simple program with which suppliers can work. The working of the support system can be found in Chapter 6. *The development of the support system.*

Conclusion and discussion

The best way to support the supplier in choosing his most promising bid is to combine every component of the support system. First the supplier has to seek the direction he has to look at, to find his most promising bid. This can be done with the help of the explanation and the graphical explanation of the award mechanisms. After that, the score of the remaining alternatives can be calculated with the calculation model.

When suppliers are optimising their bid it is important to know the working of the award mechanism. The different variables in the formulas of the award mechanisms can influence the direction for better performance. It is clear that suppliers want to know how important quality and price is, to be able to optimise their bid. Therefore they should not only look at the weight of the price and quality, but also at the other variables. If the direction for better performance changes by a variable than the importance of price and quality changes with it. That is why we implemented the influence of all the variables in the support system.

We recommend to implement the support system, developed in this thesis, into the system of Negometrix. The support system helps the supplier to put forward a better score and this is also positive for the buyer, because he gets an offer with also a higher score. This can improve the economic situation in terms of competition for Negometrix.

In addition, we will discuss some recommendations on how to improve the support system in future research:

- Future research should also focus on other award mechanisms. In this way the support system is not only restricted to suppliers using the software of Negometrix.
- To be able to improve the support system and to know what the advantages and disadvantages of the support system are, the support system should be tested and criticized by suppliers.

Table of Contents

List of figures

List of abbreviations

EMAT	Economically Most Advantageous Tender
LBS	Low Bid Scoring
MPSM	Managerial Problem Solving Method
NX Ui	Negometrix Utility index
SME	medium-sized enterprises
WFM	Weighted Factor Method
Q_{best}	Best quality
Q_i	Quality index
P_i	Price index
P_{best}	Best price
WP	Weight of price
WQ	Weight of quality
P_{setmax}	Maximum price
P_{setmin}	Minimum price

List of formulas

1. Formula of the NX Ui $Ui = \left(\frac{1-(Q_{best}-Q_i)*N}{P_i}\right) * P_{best}$

2. Formula of the price deficit $Price\ deficit = P_i - (\frac{NX\ Ui\ score}{Ui_{best}} *\ P_i)$

3. Best Buy price of the NX Ui $Best\ Buy\ price = (\frac{NX\ Ui\ score}{Ui_{best}} *\ P_i)$

4. Formula of the WFM $WFM = WQ * Q_i + WP * \frac{(P_{setmax}-P_i)}{(P_{setmax}-P_{setmin})}$

5. Best Buy price of the WFM $Best\ Buy\ price = P_i - (WFM_{best} - WFM) * \frac{(P_{setmax}-P_{setmin})}{WP}$

6. Formula of the LBS $LBS = \frac{P_{best}}{P_i} * WP + WQ * Q_i$

7. Best buy price of the LBS $Best\ Buy\ price = \frac{P_{best}*WP}{(Score_{best}-WQ*Q_i)}$

8. The margin of profit $Margin\ of\ profit = \frac{profit}{total\ turnover} * 100\%$

9. The total turnover $total\ turnover = \frac{costs}{(1-margin\ of\ profit)}$

1. Introduction

In this chapter we are first introducing the company Negometrix where the research is conducted. After that, we will discuss what the research entails, the motivation of it and purpose. Furthermore, we will discuss the goal of the research and the research questions.

1.1 Company description

Negometrix is an electronic platform where buyers can carry out a tender and enable the suppliers to provide a bid. Negometrix allows the use of seven different award mechanisms to determine the best bid. The mission of Negometrix is to create value by structured gathering of supply and demand in a smart way, creating effective agreements and relationships.

Buyers make the decision to carry out a tender with the software of Negometrix. Suppliers, on the other hand, are more or less obliged to work with the software of Negometrix. This sometimes raises resistance from the supplier's side. That is why Negometrix wants a good support system to make it easy for suppliers to work with their software and award mechanisms.

1.2 The research

Currently, the support of the various award mechanism for the buyers and suppliers is the same. This is limited to a brief explanation about the award mechanisms and there is an example in Excel how these award mechanisms work. However, their goals are different: buyers want to get the best bid and to reach the economically most advantageous tender (EMAT). Suppliers on the other hand want to win the tender. As a result, buyers need to optimise their choice which award mechanism they have to use and the suppliers need to optimise their bid which they are going to provide. This means that the suppliers need a different support system than the buyers.

For the assignment, we are only going to focus on the support system for the supplier's side. Suppliers do not have an influence on which award mechanism is used, but they frequently have a choice as to the bid they will submit. This research assignment is to design a support system for suppliers. As a result they can make an easier choice which bid they should provide and optimise it. The research methodology is based on the managerial problem solving method (MPSM) (Heerkens & Winden, 2012).

1.3 Research motivation and purpose

The supplier often has various options in which bid they will provide. For example, a cheap product with a low quality, or a more expensive product with a high quality. Depending on the award mechanism that the buyer will use, one bid can have a better score on one criterion while the other bid scores better on another criterion. Suppliers know which award mechanism the buyer uses to choose the best bid and reach the EMAT, since buyers are obligated to be transparent in their choice for an award mechanism (Mateus, Ferreira & Carreira, 2010). Some award mechanisms are more difficult to understand than others. As a result, some suppliers have a lack of insight/understanding of the award mechanisms and does not know for sure what his best option is. Therefore, there is a chance that the supplier does not provide their most promising bid and their probability of winning the tender will be lower.

The importance to optimise the supplier's bid is evident. Putting forward a better score results in a better chance at winning the tender[1]. This will also be positive for the buyer, because they get a bid with the highest score possible. Therefore, the supplier must be able to see and understand what effects it has when they provide a slightly different bid with the same award mechanism provided by the buyer.

[1] The probability of winning a tender for a supplier will not increase if every supplier optimises their bid. However, some suppliers will be able to optimise their bid better than others.

For Negometrix it is important to support the suppliers in this process. This can result in better results for the supplier and better results for the buyer. Also it can improve the economic situation in terms of competition for Negometrix. The support system that need to be developed for the suppliers can also be used by companies other than Negometrix. Therefore, the general usability and utility increases by means of the development of the support system.

1.4 Problem-solving approach

The goal of this research is to design a support system that Negometrix can provide to suppliers, in order to inform the supplier about the most promising bid. Upon achieving this goal the supplier can provide his most promising bid. This could increase the probability of winning a tender for a supplier.

With this information, we have come up with the following main research question: 'How to design a support system of the various award mechanisms in a way that the supplier knows which bid will be most promising?' To answer the main research question; we need certain knowledge, we need to perform certain activities and we need to make certain decisions (Heerkens & Winden, 2012). The required knowledge is listed below. The activities and the decisions are briefly discussed in this chapter.

1. **What are the differences between the award mechanisms?**
   - 1.1. What are the award mechanisms?
   - 1.2. Which award mechanisms are used most often?
   - 1.3. What are the characteristics of these award mechanisms?
   - 1.4. How do these various award mechanisms work?
2. **What is the current situation?**
   - 2.1. How are suppliers supported in choosing their most promising bid?
   - 2.2. What do suppliers think about the existing platform and the support given to them?
     - 2.2.1. What do suppliers think about the support given by Negometrix?
     - 2.2.2. Are suppliers asking for support about the working of the award mechanisms?
     - 2.2.3. How do suppliers optimise their bid and are they facing difficulties optimising their bid?
     - 2.2.4. What kind of support are suppliers looking for in choosing their most promising bid? / What does the supplier think are critical/necessary components in the support system?
   - 2.3. Are there already support systems for suppliers for choosing the most promising bid?
     - 2.3.1. Which components of these existing support systems are useful for the development of the support system for the suppliers?
3. **What should be the characteristics of the support system?**
   - 3.1. How to choose the most promising bid according to literature?

In the first part of the research a literature review about award mechanisms is conducted. The current situation is analysed in the second part of the research. During this stage we will conduct interviews. In the third part of the research we will research what the characteristics of the support system should be. This will be done by conducting a literature review. When all the information is gathered, a support system for suppliers will be developed. That will be the fourth and final stage. In this stage we need to make decisions on how the support system is going to look like. A detailed research design is described in Chapter *2. Research design*.

2. Research design

To perform a good research, the research design should be clear, specific and concrete (Heerkens & Winden, 2012). The research design is designed according to the MPSM and consist out of four stages: a research about the award mechanisms, an analysis of the current situation, a research about the characteristics of the support system and the development of the support system. These stages are extensively described in this chapter and can also be seen in Figure 2.

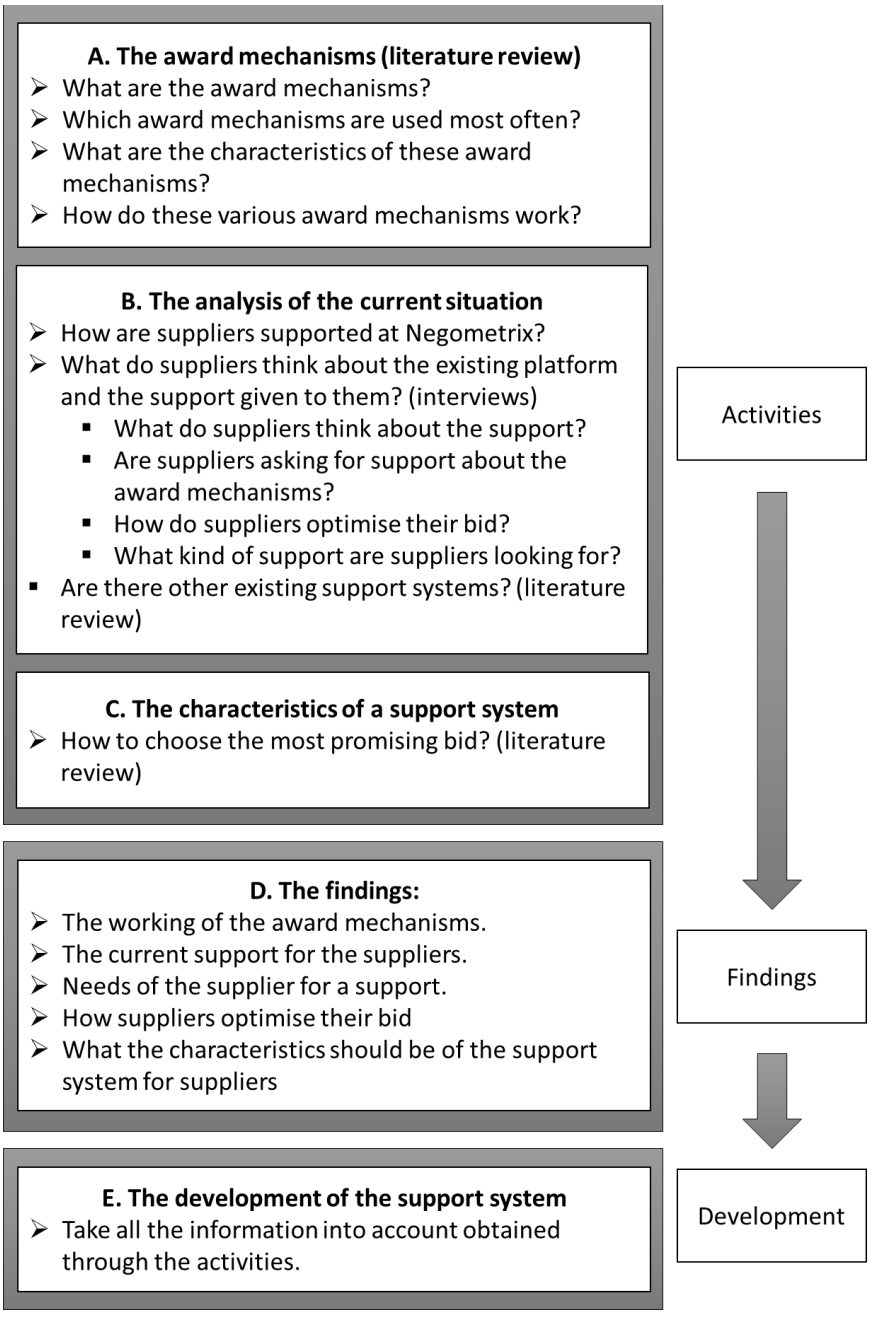

Figure 2 research design

2.1 The award mechanisms

In the first part of the research we want to create a clear view about the award mechanisms which are used by Negometrix, see part A of Figure 2. This is a descriptive research, because we want to find information about the award mechanisms, what their characteristics are and how they work (Cooper and Schindler, 2014). This is done by conducting a literature review (Heerkens, *Data gathering methods: Literature study*, n.d.). Therefore, the data gathering method will be qualitative (Cooper & Schindler, 2014). In relation to time pressure, we will only focus on the award mechanisms that have been used most often.

We will elaborate on the formulas of the award mechanisms and how it works. This will be graphically displayed. In this way the supplier can understand the working of an award mechanism faster. Furthermore, we will elaborate on the variables in the formulas and how this can influence the scores of the procurement. This will also be graphically displayed. Finally we will compare the award mechanisms to research what the differences are between the award mechanisms. It is important for the suppliers to know the differences between the award mechanisms, because than they are able to adjust their bidding behaviour for different tenders and optimise their bid to increase their score.

2.2 Analysis of the current situation

The analysis of the current situation embraces the second part of the research, see part B of Figure 2. The goal is to have a clear view about the current support provided to suppliers. This is a descriptive research as well, because the only goal of this part of the research is the current situation and the perception of the suppliers about the core problem.

2.2.1 The support provided by Negometrix

In order to get a clear picture of the support currently provided by Negometrix for suppliers, it is first investigated what the role and place is of the support system in the software of Negometrix. Subsequently, it is examined which documents suppliers have at their disposal and what content they contain. Finally, a critical view is taken on how the support, currently provided by Negometrix, is being used and whether there are parts of information missing. Therefore, the data will be gathered using the qualitative method (Cooper and Schindler, 2014).

2.2.2 Interviews with suppliers

We are also performing individual in-depth interviews with suppliers. The contact details of the suppliers are obtainable by my supervisor of Negometrix. The goal is to get a good understanding about what the supplier thinks is necessary and useful in a support system to optimise their bid. It is also important to know how the supplier wants the information to be displayed. Therefore, the data will be gathered using the qualitative method (Cooper and Schindler, 2014).

It is important to consider how an interview should be conducted. A face-to-face interview has the benefit that verbal and non-verbal behaviour can be observed. Nevertheless, an interview through the telephone or an online interview gives the opportunity to conduct more interviews in the same time frame (Cooper and Schindler, 2014). Face-to-face interviews has the preference, since we do not have to conduct a lot of interviews,

Before the interviews are conducted, the structure of the interview need to be defined. We are going to use a semi structured interview that has at the beginning a few open question and then follows more customized/specific questions for the participant to draw out more detail (Cooper and Schindler, 2014).

To conduct a successful interview we have to considerate which suppliers are useful participants for the interviews. We have to assure ourselves if the participant has the necessary information and experiences. It is not important how often the supplier has used the software of Negometrix, because the support system should also be useful for suppliers who use the software for the first time. We have to take into account if the participants are familiar with the award mechanisms, because if the supplier has knowledge of the award mechanisms they possible want a different kind of support.

Beside the selection of the participants, the motivation of the participants should also be considered. The quality and quantity of the information given by the participants during the interviews depend heavily on the motivation of the participants (Cooper and Schindler, 2014). During the introduction of the interview. We are describing the purpose of the research in a motivational way. In this way we hope that the participant gets excited and motivated.

The interviews will be recorded because in this way we do not miss any detail. It is only recorded if the participant is comfortable with this. If they are not, we will write along during the interview.

The answers of the participant must be reliable. This is difficult to control and can therefore be a limitation on this research. In order to minimize the possibility of this restriction, it can be stated that the interviews can be processed anonymously in the research. It is also important that multiple and different suppliers[2] will be interviewed to gain more than one opinion. In this way the results of the interviews will be more reliable.

It is important that the literature review of the award mechanisms and the analysis of the current situation is mostly done before the interviews are conducted, because then we have all the information that is necessary for the interviews.

2.2.3 Other support systems for suppliers

Finally, we want to elaborate on other support systems for suppliers to optimise their bid. We will conduct a literature review (Löwik, n.d.) and elaborate on other e-procurement platforms. The goal is to know which components of these existing support systems are useful for the development of our support system. This will be a qualitative data gathering method, because we want a good understanding of all the different options and their advantages and/or disadvantages (Cooper & Schindler, 2014).

2.3 Characteristics of the support system

The goal of the third part of the research is to get a clear view where the support system should consist of, see part C of Figure 2. Therefore, this will be a descriptive research (Cooper & Schindler, 2014). First we are going to research how the most promising bid should be chosen, we are going to analyse the decision the suppliers have to make. This is done by conducting a literature review (Heerkens, *Data gathering methods: Literature study*, n.d.). The data gathering method will be qualitative, because we need a good understanding of how the most promising bid is chosen (Cooper & Schindler, 2014).

With the findings of this literature review we will come to a conclusion on what the characteristics of the support system should be. This will be a qualitative data gathering method, because we want a good understanding of all the characteristics of the support system (Cooper & Schindler, 2014). The goal is to know how the support system should look like and how it should be developed.

[2] With different suppliers we mean large and small enterprises and suppliers from different sectors. Large enterprises probably have different needs than small enterprises.

2.4 Development of the support system

In the last part of the research we are going to develop a support system for the suppliers to provide their most promising bid, see part E of Figure 2. This is a descriptive research, because we want to know what should be included in the system and how it should be displayed (Cooper & Schindler, 2014). Important factors for making these decisions are the findings in the first three parts of the research, see part D of Figure 2. This means that research has yet to show how the support system should be developed. The data gathering method is qualitative, because we need to have a good understanding of the possible choices and their advantages and/or disadvantages (Cooper & Schindler, 2014).

The support system for suppliers will likely consist of:

- An explanation and instruction of the support system.
- Analytical models to calculate outcomes (decision support system).
- Graphical reproduction of the various award mechanisms.

A supplier needs support when using a support system to improve its procurement, which is why an explanation and instruction will be added to the support system. Using analytical models, the supplier can calculate what the effect will be on the score when providing a different bid, which allows the supplier to calculate his best bid. These analytical models will be made in Excel, as suppliers can handle this program. A graphical representation will be made, because in this way the supplier has a quick overview of the working of the award mechanisms that he can be faced with.

It is important that other possibilities for a support system are not excluded, because the research still has to show what kind of support the supplier needs and how it should look like.

3. The working of the award mechanisms

The following award mechanisms are used by Negometrix: NX Utility index (NX Ui), Weighted Factor Method (WFM), value based awarding, low bid scoring (LBS), log formula, value for money 50/50 and rank on score survey. In this chapter we will research which of these award mechanisms are used the most and we will research what the working of these award mechanisms are. Furthermore, we will compare the award mechanisms to see the differences.

3.1 Most commonly used award mechanisms

Because of a time limit we are developing a support system of only the award mechanisms which have been used the most on the platform of Negometrix by the buyers. To know which award mechanisms have been used the most, we are elaborating on the percentages of how often the award mechanisms are used in 2016. Figure 3 shows that the NX Ui is used around 80 percent of the time within the Negometrix platform. Which is interesting because the Low Bid Scoring formula is the most used scoring method in the world (Chen, 2008). The NX Ui, the WFM and the LBS formula have been used significantly more than the other award mechanisms. This means that we are going to develop a support system for these three award mechanisms. We will discuss the working of NX Ui, WFM and LBS respectively in the Sections *3.2 NX Utility index*, *3.3 Weighted Factor Method* and *3.4 Low Bid Scoring formula*.

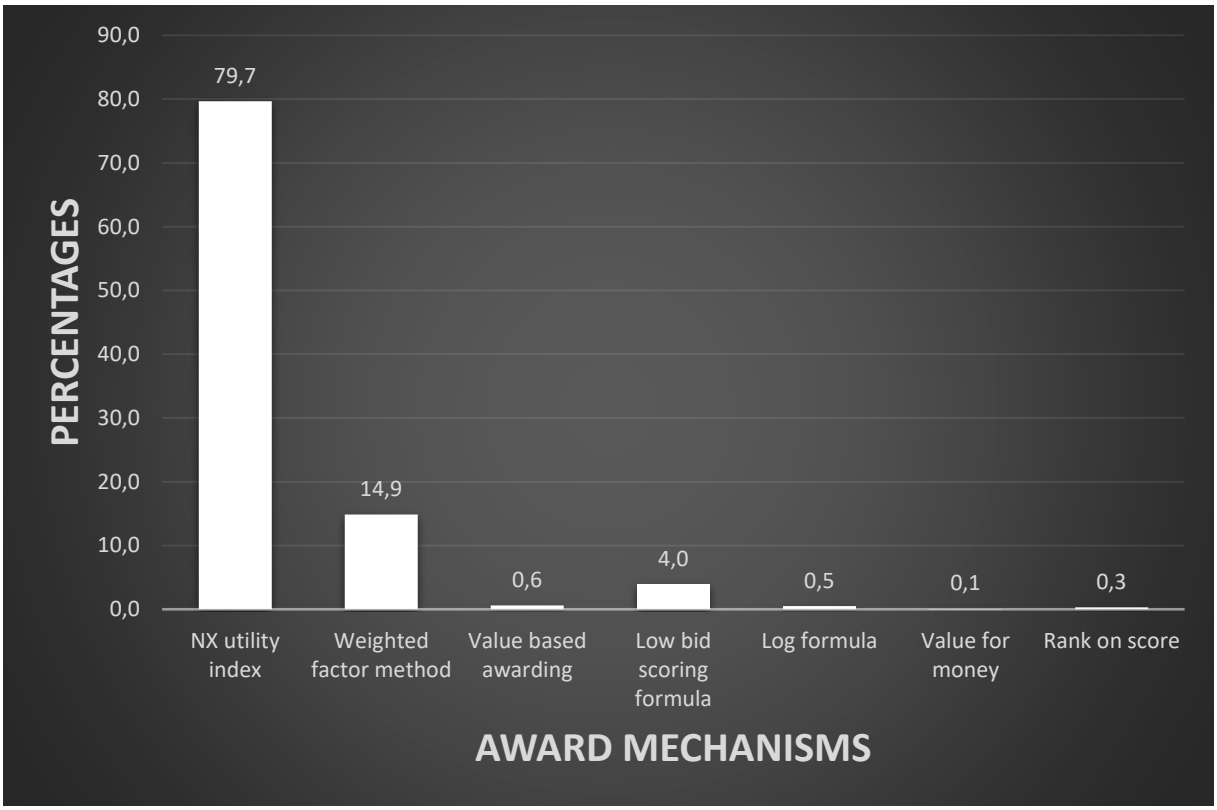

Figure 3 percentages of the use of the award mechanisms in 2016[3]

[3] This data is collected from the database of Negometrix.

3.2 NX Utility index

With the NX Utility index (NX Ui) quality is divided with price, as a result the buyer knows how much quality he gets per euro. The formula of the NX Ui used by Negometrix can be formulated as (Negometrix, *What is the Utility index?,* 2018):

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

Q_{best} = Best quality (the higher the better) from all the bids in the tender with a maximum of 100 percent.

Q_i = Quality index, the quality for bid *i*

P_i = Price index, the price for bid *i*

P_{best} = Lowest price from all the bids in the tender

N = $\frac{Weight\ of\ quality}{Weight\ of\ price}$

Ui = the score of the supplier (the supplier with the highest score will win the tender)

To make the NX Ui a meaningful number, it will be multiplied with the lowest price (P_{best}). This adjustment makes the highest Ui a value of 100 percent. A supplier gets a score of 100 percent when it offers both the lowest price and the highest quality. (Negometrix, *What is the Utility index?,* 2018)

The NX Ui is in literature also called "Value for Money", because the NX Ui and the Value for Money both divides the quality with the price. The difference between the two formulas is the price/quality ratio. With the NX Ui the price/quality ratio can be set up with the factor N. Without the factor N, quality and price is always equally important. When quality and price are equally weighted, N = 1. In that case factor N does not make any adjustments in the formula. But, when the price is four times more important, N = 20%/80% = 0,25, factor N makes adjustments in the formula. (Negometrix, *What is the Utility index?,* 2018)

If factor N has a great value the score of a bid can become negative. In this case the ranking is not reliable anymore. To prevent this, Negometrix uses the price deficit as ranking method. The formula of the price deficit is (Negometrix, *What is the Utility index?,* 2018):

$$Price\ deficit = P_i - (\frac{NX\ Ui\ score}{Ui_{best}} *\ P_i) \quad (2)$$

Ui_{best} = Score of the best bid according to the formula of the NX Ui.

The price deficit indicates how much the price of a bid is too expensive, the lower the better. To know which price a supplier should have offered to have the same score as the most advantageous offer (the bid with the highest utility index), can be easily calculated with the Best Buy price. The best buy is calculated during the evaluation of the tender, after all bids of every supplier are provided. The formula of the Best Buy price can be formulated as (Negometrix, *What is the Utility index?,* 2018):

$$Best\ Buy\ price = (\frac{NX\ Ui\ score}{Ui_{best}} *\ P_i) \quad (3)$$

In the formula of the NX Ui the parameters Q_{best} and P_{best} are used. This means that the NX Ui is a relative scoring method and that it is opaque to suppliers. Suppliers are only allowed to submit one bid per tender. Hence, they may unintentionally provide a non-optimal bid (Bergman & Lundberg, 2013). As a result, it is difficult for the supplier to provide their most optimal bid when a relative scoring method is used. Because of this, the buyer could receive bids with a lower score. That is why it is very important to offer the suppliers a good support to optimise their bid.

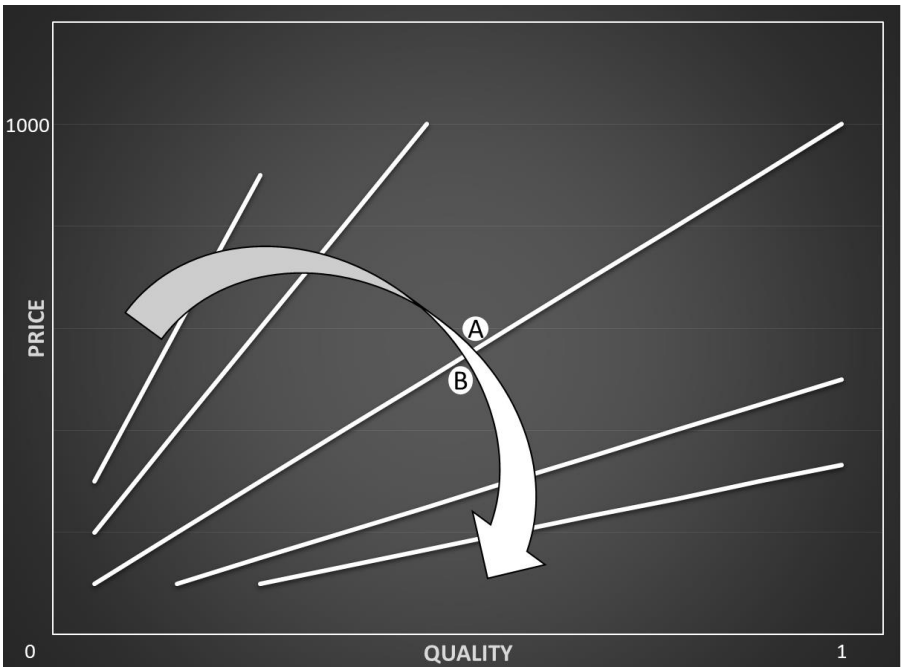

Figure 4 direction for better performance for the NX Ui[4]

Figure 4 shows the direction for better performance if the NX utility index is used. The direction for better performance shows which bid is better. The bids with the same outcome are on the same line. Looking at the graph it shows that the lines are not parallel to each other, but are shaped clockwise. The arrow in Figure 4 indicates the direction for better performance and shows that bid B is better than bid A. It is important for suppliers to know the direction for better performance, because then suppliers have indications in which direction they have to look, to find the most promising bid.

The parameters N, Q_{best} and P_{best} influence the steepness of the lines in Figure 4 and thus also the direction for better performance, see Appendix *A. Influence of the parameters on the NX Ui.* As a result it is important for suppliers to know the value of these parameters to be able to know the direction for better performance. The parameter N has been predefined by the buyer, however the Q_{best} and the P_{best} are not predefined and depend on the bids provided by every supplier. It is hard to predict the Q_{best} and the P_{best}, because we do not know for sure what the bidding behaviour of every supplier will be.

3.3 Weighted Factor Method

The second award mechanism that will be discussed is the weighted factor method (WFM). The formula of the weighted factor score used by Negometrix can be formulated as (Negometrix, *Wat is de Gewogen Factor Methode?,* 2018):

$$WFS = WQ * Q_i + WP * \frac{(P_{setmax} - P_i)}{(P_{setmax} - P_{setmin})} \quad (4)$$

WP = Weight of the price, set by the buyer
WQ = Weight of the quality, set by the buyer
P_{setmax} = Maximum price, set by the buyer
P_{setmin} = Minimum price, set by the buyer
WFS = the score of the supplier (the supplier with the highest score will win the tender)

[4] The outcomes of this graph is calculated with the formula of the NX Utility index. The price range is from 100 to 1000, the quality range is from 0 to 1 and factor N is defined as 1 (weight of quality and price is the same).

The buyer determines the expected price range when the WFM is used. The price range is the range in which the supplier can make their offer price. Additionally, the buyer has to determine a weight of the price in relation to the quality. For example, 50% for price and 50% for quality or 60% for price and 40% for quality. (Negometrix, *Wat is de Gewogen Factor Methode?,* 2018)

The score on price is based on the determined price range. The supplier makes an offer between the minimum and maximum price. Based on the price of the supplier, the system will award points for the price. In the area for quality there are various specifications, the buyer has to determine a weight for every (sub-) quality criterion. In practise, the points for quality given to the supplier, is the sum of the scores of several sub-criteria of the quality. (Negometrix, *Wat is de Gewogen Factor Methode?,* 2018)

The bid with the highest score will be ranked first and is the most advantageous offer. Also for the WFM the Best Buy price will be calculated during the evaluation of the tender. The formula for the Best Buy price can be formulated as (Negometrix, *Wat is de Gewogen Factor Methode?,* 2018):

$$Best\ Buy\ price = P_i - (WFM_{best} - WFM) * \frac{(P_{setmax} - P_{setmin})}{WP} \quad (5)$$

WFM_{best} = The score of the best bid according to the formula of the WFM

Elaborating on the formula of the WFM we see that an absolute scoring rule is used (Telgen & Schotanus, 2010). This means that the outcome does not depend on other bids, because there are no parameters in the formula such as the best price or best quality. As a result, it is easier for suppliers to determine their most promising bid when an absolute scoring method is used. Because of this, the buyer has a higher chance that he will receive bids with the highest scores possible.

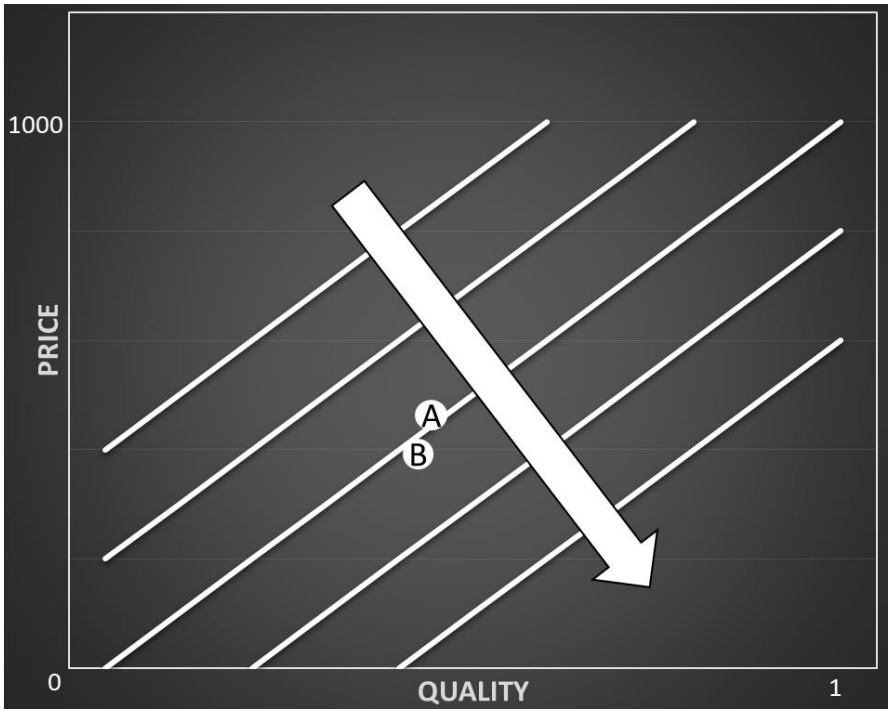

Figure 5 direction for better performance for the WFM[5]

[5] The outcomes of this graph is calculated with the formula of the WFM. The price range is from 0 (P_{setmin} = 0) to 1000 (P_{setmax} = 1000), the quality range is from 0 to 1, the weight of price is 0,5 and the weight of quality is 0,5.

Figure 5 shows which bid has a better score if the Weighted Factor Method is used. This is called the direction for better performance. The bids with the same outcome are on the same line. Looking at the graph it shows that the lines are linear and parallel to each other. The arrow in Figure 5 indicates the direction for better performance and shows that bid B is better than bid A. As mentioned in Section 3.2 NX Utility index, it is important for suppliers to know the direction for better performance, because then suppliers have indications in which direction they have to look, to find the most promising bid.

The parameters WP, WQ, P_{setmax} and P_{setmin} influence the steepness of the lines in Figure 5 and thus also the direction for better performance, see *Appendix B. Influence of the parameters on the WFM.* As a result it is important for the suppliers to know the value of these parameters to be able to know the direction for better performance.

3.4 Low Bid Scoring formula

The Low Bid Scoring (LBS) formula is the most used award mechanisms in the world (Chen, 2008). It is a combination of the utility index and the weighted factor method. The formula of the LBS used by Negometrix can be formulated as (Negometrix, *Wat is de Low Bid Scoring (LBS) formule?,* 2018)::

$$LBS = \frac{P_{best}}{P_i} * WP + WQ * Q_i \quad (6)$$

LBS = the score of the supplier (the supplier with the highest score will win the tender)

The score of the quality is determined by the first part of the formula: $\frac{P_{best}}{P_i} * WP$. For the bid with the lowest price applies: $P_i = P_{best}$. The number of points is then WP * 1. This is the maximum score for price. A higher price gets of course a lower score.

The score of quality is determined by the second part of the formula: $WQ * Q_i$. The weight of quality is multiplied by the score of quality. In practise it is the sum of several sub-criteria of the quality and several partial scores of bid *i* per sub-criterion of the quality.

The bid with the highest score will be ranked first and is the most advantageous offer. Also for the LBS the Best Buy price will be calculated during the evaluation of the tender. The formula for the Best Buy price can be formulated as (Negometrix, *Wat is de Low Bid Scoring (LBS) formule?,* 2018):

$$Best\ Buy\ price = \frac{P_{best} * WP}{(Score_{best} - WQ * Q_i)} \quad (7)$$

$Score_{best}$ = The score of the best bid according to the formula of the LBS

As mentioned in Section *3.2 NX Utility index*, an award mechanism is a relative scoring method if P_{best} is used in the formula. This is the case with the LBS formula. This means that the LBS formula is opaque to the suppliers and that the suppliers may unintentionally provide a non-optimal bid (Bergman & Lundberg, 2013). As a result, it is difficult for the supplier to provide their most optimal bid when a relative scoring method is used. Because of this, the buyer could receive bids with a lower score. That is why it is very important to offer the suppliers a good support to optimise their bid.

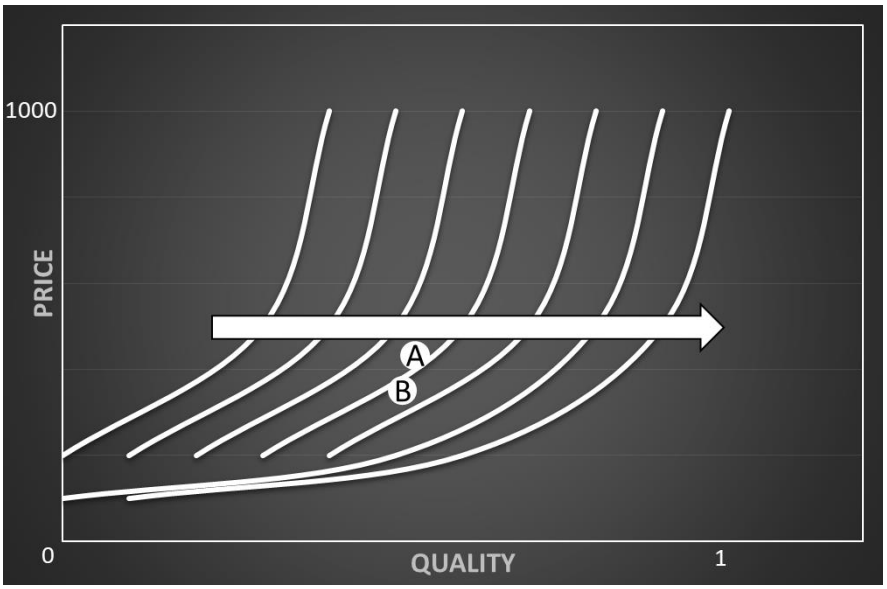

Figure 6 direction for better performance for the LBS[6]

Figure 6 shows which bid has a better score if the Low Bid Scoring formula is used. This is called the direction for better performance. The bids with the same outcome are on the same line. Looking at the graph it shows that the lines are an arc. The arrow in Figure 6 indicates the direction for better performance and shows that bid B is better than bid A. As mentioned in Section 3.2 NX Utility index, it is important for suppliers to know the direction for better performance, because then suppliers have indications in which direction they have to look, to find the most promising bid.

The parameters WP, WQ and P_{best} influence the steepness of the lines in Figure 6 and thus also the direction for better performance, see *Appendix C. Influence of the parameters on the LBS formula.* As a result it is important for the suppliers to know the value of these parameters to know the direction for better performance. The parameters WP and WQ has been predefined by the buyer, however P_{best} is not predefined and depend on the bids provided by every supplier. It is hard to predict P_{best}, because we do not know for sure what the bidding behaviour of every supplier will be.

Looking at Figure 6, if the price set by the supplier is low and he wants a significantly higher score, he needs to raise his quality a lot. This is peculiar, because a low price is profitable for the buyer and if the price stays the same and the quality rises, the score of the bid should raise a lot. This is important information for developing the support system for the suppliers to optimise their bid, because suppliers can adjust their bidding behaviour to this.

3.5 Differences between the award mechanisms

In this section we are going to compare the various award mechanisms to be able to see the differences. A supplier is during a tender only faced with one award mechanism. Thus why is it interesting to compare the award mechanisms? Because we want to know if a supplier needs a different kind of support when a different scoring method is used. This is important information for the development of the support system for suppliers to optimise their bid. As a result, we will elaborate on the differences based on the direction for better performance to see if the same bid has a different outcome. Further, we will elaborate on the difference between absolute and relative scoring methods.

[6] The outcomes of this graph is calculated with the LBS formula. The price range is from 100 to 1000, the quality range is from 0 to 1, the weight of price is 0,5 and the weight of quality is 0,5.

Figure 7, 8 and 9 show the comparison of the award mechanisms based on the direction for better performance. It is clear that the direction for better performance for the various award mechanisms is very different. This means that the same bid can have a higher or lower score when a different award mechanism is used. As a result, it is very important for the supplier to know which award mechanism is used by the buyer to select the EMAT and how it works, because than the supplier can adjust their bidding behaviour to be able to provide their most promising bid.

In Section *3.2 NX Utility index, 3.3 Weighted Factor Method* and *3.4 Low Bid Scoring formula*, we saw that the NX Utility index and the Low Bid Scoring formula are relative scoring methods. The Weighted Factor Method is an absolute scoring method. The difference is that it is easier for suppliers to determine what the most promising bid is with an absolute scoring method than with a relative scoring method, because the outcome of a relative scoring method depends often on the best price and/or best quality. The best price and best quality are difficult to determine, because the bidding behaviour of supplier are hard to predict (Lin & Chen, 2004). Another difference between the two scoring methods is that a relative scoring method can lead to rank reversal. This is important information that will be used during the development of the support system for suppliers

We come to the conclusion that it is very important for suppliers to know the differences of the award mechanisms and that they are aware of the fact that they need to adjust their bidding behaviour for every tender. However, we will not go into any more detail of the differences of the award mechanisms, such as the different parameters, because a supplier only faces one award mechanism in a tender.

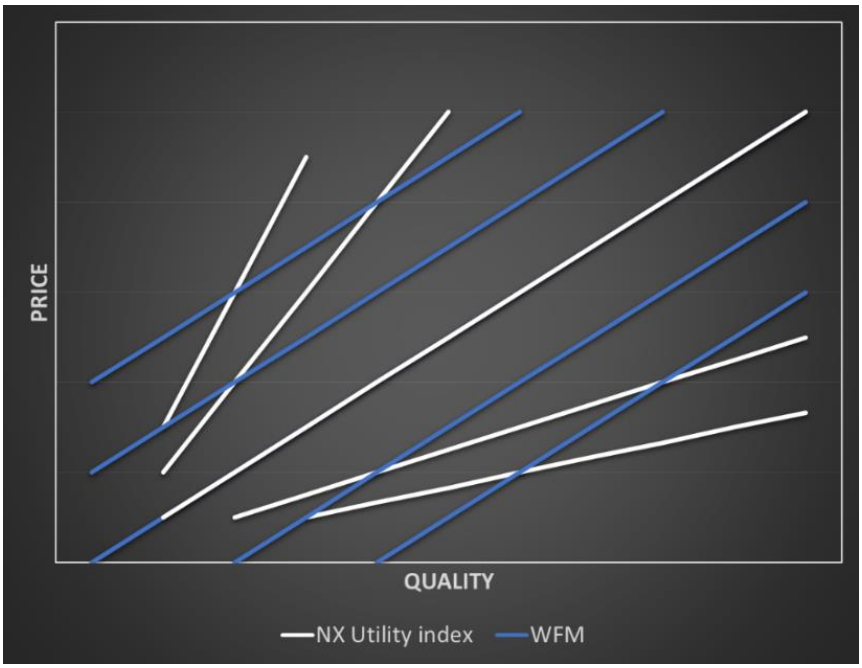

Figure 7 comparison between the NX Ui and the WFM[7]

[7] This graph is a combination of Figure 4 and 5.

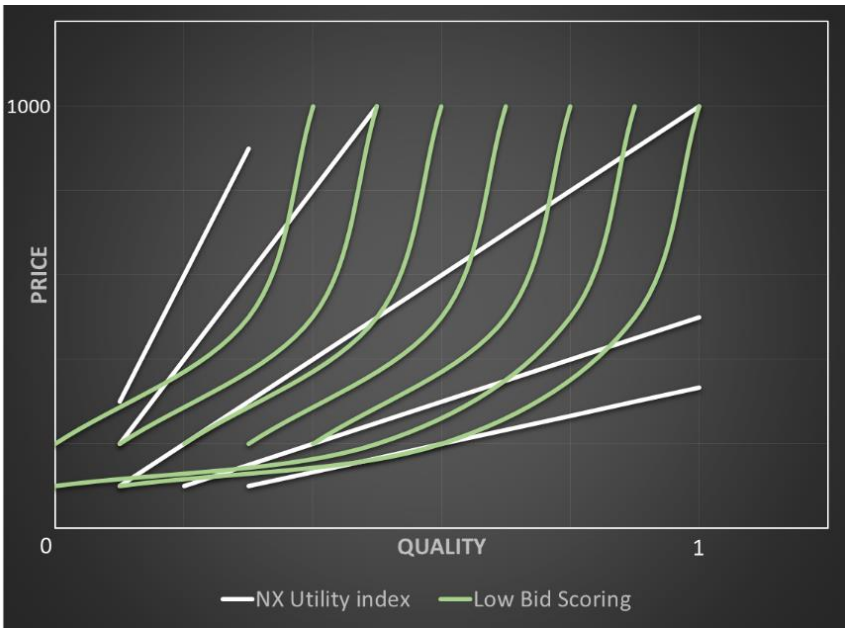

Figure 8 comparison between the NX Ui and the LBS[8]

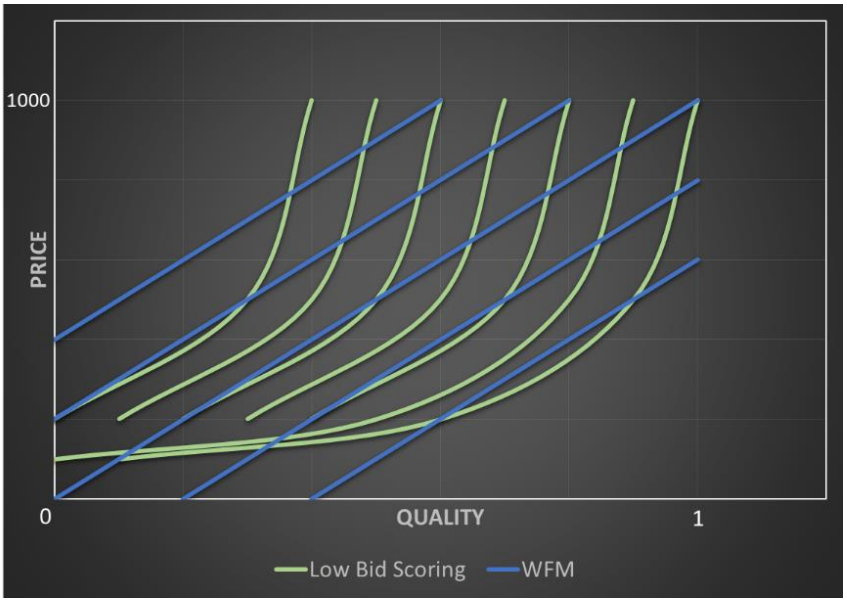

Figure 9 comparison between the LBS and the WFM[9]

[8] This graph is a combination of Figure 4 and 6.
[9] This graph is a combination of Figure 5 and 6.

4. The current situation

To be able to develop a support system for suppliers we need to map the current situation. We will do this by elaborating on how the suppliers are supported by Negometrix and performing five individual depth interviews with suppliers. Furthermore, we are going to research if there already are existing support systems for suppliers to optimise their bid.

4.1 How are suppliers supported in choosing their most promising bid?

To make a support system that meets the expectations of the suppliers, we need to know how the suppliers are supported by Negometrix. We will research the role and place of the current support of Negometrix for suppliers. At this moment there is a helpdesk and there are instruction documents. We will discuss the working of the helpdesk and the content of the instruction documents below.

The suppliers are able to call or mail the service desk (helpdesk) of Negometrix. This service desk is open from 08:00 to 18:00. Here they can ask their questions to the employees of Negometrix about a tender or about the software of Negometrix. This service is used very often by suppliers, namely around one thousand times per month. This takes a lot of time for the employees of Negometrix. When these calls can be reduced by means of a better support for suppliers. The employees have more time for other important tasks within the company.

There are instruction document in general. The topics of these documents are: register, log in, colleagues, organisation and browser. There are also instruction documents especially for suppliers. The topics of these documents are: register, question & answer, tenders, submit offer, organisation and colleagues (Negometrix, *Knowledge base*, n.d.). There are no documents about the award mechanisms and how they work particular for suppliers. While it is important for suppliers to understand the award mechanisms to be able to provide their most promising bid.

However, there is an instruction document about the award mechanism NX Utility index (NX Ui) for buyers in English (Negometrix, *Knowledge base*, n.d.). This document explains how the NX Ui works, but there are no instruction documents of the other award mechanisms in English only in Dutch. Further, there is a calculation sheet in excel with all the award mechanisms, see *Appendix D. Calculation sheet of Negometrix*. With this calculation sheet a buyer can fill in various parameters and play with the award mechanisms. This results in a better understanding of the formulas. These documents and this calculation sheet are also obtainable for suppliers. This means that suppliers can use these attributes to improve their understanding of the award mechanisms.

Like mentioned above there are also instruction documents for suppliers about how to ask questions to buyers and get answers. Suppliers are able to ask questions about the tender. For example, about the information given to them by buyers or about the information the suppliers have to provide to the buyers. This means that suppliers are, in a way, also supported by the buyers.

We come to the conclusion that the suppliers are supported in many ways: they can call the service desk of Negometrix, they can ask questions to buyers and they can use instruction documents available on the website of Negometrix. However, they are not supported in optimising their bid. The supplier can use the instruction document about the award mechanisms and the calculation sheet of the award mechanisms, but the calculation sheet is not especially made for suppliers and there is/are no support/instructions for optimising their bid.

4.2 What do suppliers think about the support given to them?

In order to be able to develop a good support for suppliers, it is important that the aspects that need to be considered according to the suppliers are researched. This is done by conducting five individual depth interviews with suppliers. The methodology of the interviews are described in *2.2.2 Interviews with suppliers*. The interviews are conducted with various participants/suppliers who would like to stay anonymous. We will summarize the interviews per research question below. The research questions are recorded in Section *1.4 Problem-solving approach*.

4.2.1 Summary of the interviews

The first research question is: ***What do suppliers think about the support given by Negometrix?*** In general, the supplier are very satisfied with the support given to them. They think the helpdesk is very useful, because in this way their questions are answered very quickly. One supplier thinks that the software and the support of Negometrix is especially focused on buyers. This is quite logical for Negometrix, because buyers are the customers for Negometrix. Another supplier said that they do not use the instruction documents about the award mechanisms and the calculation sheet of the award mechanisms, because they did not know it existed. This means it is important that these documents are at a convenient location in the software and are offered by Negometrix when a supplier registers to the platform of Negometrix.

The next research question is: ***Are suppliers asking for support about the working of the award mechanisms?*** It is clear that small and medium enterprises (SME's) are asking for more support about the award mechanisms, because SME's often have no bid managers and therefore less knowledge about the award mechanisms. This means that it is very important and useful to have an explanation of the various award mechanisms in the support system. In this way we can especially help SME's to get a better understanding of the various award mechanisms that are used by buyers to select the EMAT. Large companies often have bid managers who have a lot of knowledge about the award mechanisms. As a result, large companies do not ask for much support about the working of the award mechanisms.

The third research question is: ***How do suppliers optimise their bid and are they facing difficulties optimising their bid?*** Bid managers have to be constantly critical. They keep an eye on whether they meet the conditions, whether they show their added value and whether the references/documents are correct. It is clear that large enterprises elaborate on the award mechanism to optimise their bid.

The main focus is on what the weight of quality and price is. As seen in Chapter 3. *The working of the award mechanisms*, the weight of quality and price influence the direction for better performance and are important factors to be able to optimise a bid. When price has a low weight they are able to provide a more cost-effective price. One supplier thinks that it is sometimes difficult to determine the weight of the quality and price, because not every award mechanism is transparent. This means that it is important that the supplier knows what the weight of the price and the quality is. In the end, the supplier wants a profitable customer and has to carefully think about the price which he is going to offer and if this price is low enough. Sometimes, when the supplier wants a customer in their portfolio, he will be prepared to have a lower return on it. As a result, it is important to find the right balance between quality and price.

Another supplier thinks it is not possible to play with the quality when providing a bid. They ensure that the quality is as high as possible and find a price that fits best. Their cost price is leading. This differs per supplier and per sector. Some suppliers do have the opportunity to play with the quality.

The last research question is: ***What kind of support are suppliers looking for in choosing their most promising bid? / What does the supplier think are critical/necessary components in the support system?*** It is clear that SME's need more support than large enterprises, due to lack of insight/understanding of the award mechanisms. One supplier thinks it is useless to be able to insert the bidding behaviour of the other suppliers in the support system, because the bidding behaviour of the other suppliers cannot be predicted. The bidding behaviour of the other suppliers can be very different in this tender than in another tender. Another supplier wants to know more about how the buyers deal with the award mechanisms. Generally, the suppliers want a good explanation of the various award mechanisms and want a good support to be able to compare various options. They want a mathematical explanation in combination with a graphical explanation.

4.3 Already existing support systems for suppliers

To get a complete picture of the current situation, we are going to elaborate on already existing support systems for suppliers to choose their most promising bid. The goal is to know which components of these existing support systems are useful for the development of our support system.

During the literature review we found bid/no-bid decision making tools for suppliers/bid managers. These tools help suppliers to decide if they should enter a tender or not (Lin & Chen, 2004). How these kind of tools work is not interesting for this research, because we elaborate on how to optimise a bid and not if a supplier should make a bid. Nevertheless it can be interesting to elaborate on the different forms of a bid/no-bid decision tool. The various forms are (The One Business Proposal, 2018):

- A checklist: This form is a simple set of questions.
- A matrix: This form will assign weights to the questions and calculates a final score
- A decision tree: This form organises a logic flow that leads to a decision.

A decision tree is an interesting form for our support system, because it can be combined with other decision techniques. It is also simple for suppliers to understand, to use and it can show the expected outcome for different scenarios. However, a decision tree has also disadvantageous. For example, they are often relatively inaccurate. That means it is important to combine a decision tree with other decision techniques. In this way we prevent the support system from being inaccurate. (The One Business Proposal, 2018)

There are many decision support systems to evaluate a tender and for supplier selection for procurement managers (the buyers) (Ghodsypour & O'brien, 1998) (Weber & Ellram, 1993) (Chou & Chang, 2008). However, we did not find any support systems for suppliers that help them to optimise their bid. This does not mean that there are no support systems for suppliers to optimise their bid. As a result, we cannot obtain any information for the development of our support system from already existing support systems for suppliers to optimise their bid.

5. How to develop a support system for suppliers to optimise their bid?

We want to develop a support system to help suppliers to make decisions about which bid they should provide. Therefore, we must research how we should develop such a support system. This is done by conducting a literature review about how suppliers choose their most promising bid according to literature (Löwik, n.d.). The goal is that it is clear where the support system should consist of and how it should look like.

5.1 How to choose the most promising bid

The problem we are facing is that we need to assist the supplier to provide the most promising bid. And in this section we are going to analyse the decision the supplier has to make to provide a bid with the highest probability of winning the tender. Because, with a decision analysis it is possible to replace confusion by clear insight into a desired course of action (Howard, 1988).

According to Howard (1988), to be able to analyse the decision we need to know what the alternatives are. This is quite simple, because the alternatives are the various bids the supplier can provide. Also we need to know the preference of the decision-maker. The decision-maker is the supplier and the preference of the supplier is to make a decision before the deadline, to select the most promising bid. Further, we need to collect certain information that will be important to characterize the connection between decisions and outcomes. The information can be any models, probability assignments or relationships (Howard, 1998). This will be described below.

The supplier is of course in competition with other suppliers and when the supplier is providing a bid, it is important to consider what the action of the competition will be. Especially when the procurement manager uses a relative scoring method. The outcome of a relative scoring method depends on the bids provided by every supplier. This information leads us to two different decision-making techniques, namely Game Theory (Osborne, 2000)) and decision making under uncertainty (Winston & Goldberg, 2004).

Game Theory can be a valuable decision-making technique, because Game theory allows me to analyse situations in which the decisions of multiple agents affect the pay-off of each agent (Osborne, 2000). In this case the agents are the suppliers. Also decision making under uncertainty can be a valuable decision-making technique. The supplier is uncertain about certain factor that is relevant to the decision, for example what the other suppliers will bid. Decision making under uncertainty helps to make a decision in the absence of this certainty (Winston & Goldberg, 2004).

However, it is difficult to predict the bidding behaviour of competitors, because it is not always the same and therefore historical data of competitors cannot be used (Lin & Chen, 2004). This is also mentioned in Section *4.2.1 Summary of the interviews*. Nevertheless, it is possible to make assumptions about the bidding behaviour of the other suppliers. The supplier could simulate extremes and standard tenders and use this information when he is optimising his bid, but it remains uncertain.

Although it is uncertain what the other suppliers will bid, it is certain that the supplier has to have a score as high as possible to maximise the probability of winning a tender, because the bid with the

highest score will win the tender.[10] And because the award mechanism the buyer uses to select the EMAT is predefined, our problem can be limited to choosing the option that gives the supplier the most amount of points.

When there are only a few alternatives, there will be enough time for suppliers to seek the best option through all the alternatives. This lead us to the decision-making technique, maximizing. All the options can be calculated and the alternative with the highest score is the only acceptable one (GUO, 2008).

However, there can be a lot of alternatives for the supplier, for example because there are all kinds of possible quality levels with different prices that could be provided by the suppliers, see Chapter 3. *The working of the award mechanisms*. When there are too many alternatives the supplier cannot seek the best option through all the alternatives, because of time pressure. In this case the supplier needs a support to choose the best option through all the alternatives (Howard, 1988). We will discuss which kind of support this should be, in Section *5.2 How the supplier should be supported.*

5.2 How the supplier has to be supported

The suppliers need a support to be able to select the best option out of many alternatives. This support needs to consist out of logical operations (Howard, 1988). These logical operations need to give an indication in which direction the suppliers have to look at, to find the most promising bid. This is possible through knowing how the award mechanisms work. When suppliers know how the formula works and how the direction for better performance for the award mechanism can be determined, they also know in which direction they have to look at, to find the most promising bid, see Chapter *3. The working of the award mechanisms*.

Learning to understand the working of the various award mechanisms can be done in two different ways:

- Explanation of the mathematical form of the award mechanisms
- Graphical explanation of the award mechanisms

Both ways have advantages and disadvantages. An explanation of the mathematical form of the award mechanisms has the advantages that it is precise and can explain how the formula works. The disadvantages of a mathematical explanation are that it is often not visually appealing and the mathematical relationship are not clear. A graphical explanation of the award mechanisms has the advantages that it can explain mathematical relationships and it is visually appealing. The disadvantages of a graphical explanation are data misinterpretation and complacency. (Tucker, 2018)

Some suppliers want to see the explanation of the award mechanisms in a mathematical form, others in a graphical form and others in both forms. That is why, these two ways can complement each other well in the support system.

[10] In Chapter 3. *The working of the award mechanisms,* we mentioned that the supplier with the highest score wins the tender.

5.3 Calculations

If suppliers know in which direction they have to look, to find the most promising bid, they can make the final step by putting the remaining alternatives side by side. This will lead back to the decision technique: maximizing. All the options can be calculated and the alternative with the highest score is the only acceptable one (GUO, 2008). To be able to calculate the score of every alternative, a calculation model of the award mechanisms is needed. This is the final step for deciding which bid is the most promising one.

It can occur that various bids/alternatives have the same score, see Chapter *3. The working of the award mechanisms*. When various alternatives have the same score, the chance of winning the tender is the same and the supplier has to choose between these alternatives based on his own preference. For example, the supplier will make a bigger profit with bid one than with bid two. The probability of winning the tender is the same. However, the supplier will choose for bid one, because the profit will be bigger. If there are two bids with the same score the supplier can therefore for example watch at their own cost structure. The cost structure of every supplier is different and therefore difficult to implement in the support system. However, we could implement a simple basis cost structure what can be used by all suppliers and what the supplier can expand itself.

5.4 Conclusion

Based on the findings in this chapter, we suggest to provide a support for each award mechanism that consists out of:

- An explanation of the award mechanisms (algebra, prose)
- A graphical representation of the award mechanisms
- A calculation model to calculate the score of the bids

In Chapter 3. *The working of the award mechanisms,* we did research about the working of the award mechanisms. This information can be used to develop an explanation of the award mechanisms and a graphical representation of the award mechanisms. In Chapter 4*. The current situation*, we did research about how the suppliers are supported at this moment and how the suppliers want to be supported. We will take this information into account during the development of the support system.

6. The development of the support system

Now we have all the information and knowledge to begin with the last part of the research, the development of the support system for the suppliers. In this chapter it is described how the support system is developed and how it works.

6.1 How is the support system developed

To be able to develop the support system, we used the information found in Chapter *3. The award mechanisms,* Chapter 4. *The current situation* and Chapter *5. How to develop a support system?*. The most important factors when developing the support system are: the wishes of the suppliers, the wishes of Negometrix, the interests of the customers of Negometrix and what the characteristics of the support system should be.

*W*e came to the conclusion that the support system for suppliers to choose their most promising bid, should consist of: an explanation of the award mechanisms, a graphical representation of the award mechanism and a calculation model to calculate the scores of the bids. This support system is made in Excel, because it is a simple program with which suppliers can work. The working of this support system is described below.

6.2 Explanation of the award mechanisms

As described in Section *6.1 How is the support system developed*, the support system begins with an explanation of the award mechanism. See Figure 10 for the explanation of the NX Utility Index in the support system.

First the formula is described and what the variables means. Further, there is an explanation about the direction for better performance and the influence of different parameters on the direction for better performance of the NX Utility index. Furthermore, the price deficit and the Best Buy price are explained and the purpose of these formulas.

Also, there is an explanation about how the supplier should determine their most promising bid. This is done according to five steps described below:

- Step 1: Have a good understanding of the working of the NX Utility index.
- Step 2: Determine the value of the parameter N. This is predefined by the buyer.
- Step 3: Consider what the best quality and the best price could be. This is difficult to predict, because we cannot know for sure what the bidding behaviour of the other suppliers will be.
- Step 4: Determine, with the help of the direction for better performance, the direction in which you have to look at, to find the most promising bid.
- Step 5: Use the calculation model of the NX Utility index to calculate the outcome of the remaining alternatives and choose the option with the highest score.

These five steps and the mathematical explanation of the award mechanism helps the supplier in which direction he has to look, to find his most promising bid.

Explanation of the NX Utility Index

With the NX Utility index (NX Ui) the quality is divided with the price, as a result the buyer knows how much quality he gets per euro.

Formula =	((1-(Qbest-Qi)*N)/Pi)*Pbest
Qbest =	the highest quality from all the bids in the tender
Qi =	quality index, the quality score from the relevant supplier
N =	WQ / WP
Pi =	price index, the price score from the relevant supplier
Pbest =	the lowest price from all the bids in the tender
WQ =	the weight of the quality set by the buyer
WP =	the weight of the price set by the buyer

The direction for better performance

The direction for better performance shows which bid has a better score, see figure 1.
The arrow in figure 1 indicates the direction for better performance.
The bids on the same line has the same outcome. The lines are linear and shaped clockwise.

Influence of factor N

The factor N determines the weight of the quality and the price
If factor N = 1, then WQ = 0,5 and WP = 0,5. See figure 1. In that case the factor does not make any adjustments in the formula.
If factor N > 1, then WQ > 0,5 and WP < 0,5. In this situation the lines for the direction for better performance are steeper than in figure 1.
If factor N < 1, then WQ < 0,5 and WP > 0,5. In this situation the lines for the direction for better performance are more horizontal than in figure 1.

Price deficit

If the N has a great value the score of a bid can become negative. In this case the ranking is not reliable anymore.
To prevent this, the price deficit is used to determine the ranking

Formula =	Pi - (NX Ui score/Uibest * Pi)
Uibest =	the score of the best bid according to the NX Ui.

Best Buy price

The bid with the highest score will be ranked first and is the most advantageous offer.
During the evaluation the Best Buy price will be calculated.
With the Best Buy price the supplier knows which price he should had offered to have the same score as the most advantageous offer

Formula =	NX Ui score/Uibest*Pi

Influence of Qbest and Pbest

If Qbest is high and Pbest is low the lines for the direction for better performance are steeper than in figure 1.
If Qbest is low and Pbest is high the lines for the direction for better performance are more horizontal than in figure 1.
The use of the Pbest en the Qbest means that the NX Ui is a relative scoring method and that it is opaque to the suppliers.
The value of the Pbest and the Qbest are depended on the bids of every supplier.
This means that the value is difficult to predict, because the bidding behaviour of the other suppliers are difficult to predict.

How to determine the most promising bid

Step 1	Have a good understanding of the working of the NX Utility index.
Step 2	Determine the value of the parameter N. This is predefined by the buyer.
Step 3	Consider what the best quality and the best price could be.
	This is difficult to predict, because we cannot know for sure what the bidding behaviour of the other suppliers will be.
Step 4	Determine, with the help of the direction for better performance, the value of the N,
	and the predicted value of the best quality and price, the direction in which you have to search to find the most promising bid.
Step 5	Use the calculation model of the NX Utility index to calculate the outcome of the remaining alternatives
	and choose the option with the highest score.

Figure 10 explanation of the NX Utility index in the support system[11]

6.3 Graphical representation of the award mechanisms

As described in Section *6.1 How is the support system developed*, the support system has for every award mechanism a graphical representation. See Figure 11 for the graphical representation of the NX Utility Index in the support system.

First, there is a graphical representation of the direction for better performance for the NX Ui. It is important for suppliers to know the direction for better performance, because then suppliers have indications in which direction they have to look, to find the most promising bid.

[11] The explanations of the other award mechanisms are made in the same way.

Furthermore, there is a graphical representation of when the factor N changes. When the factor N changes the direction for better performance also changes. If the supplier knows what the influence of factor N is, it should help him to determine the direction in which he has to look, to find the most promising bid.

Next to the graphs is an explanation for the supplier about how to understand the information in the graphs.

Graphical representation of the NX Utility index

Figure 1, the direction for better performance. With N = 1, Qbest = 1 and Pbest = 100

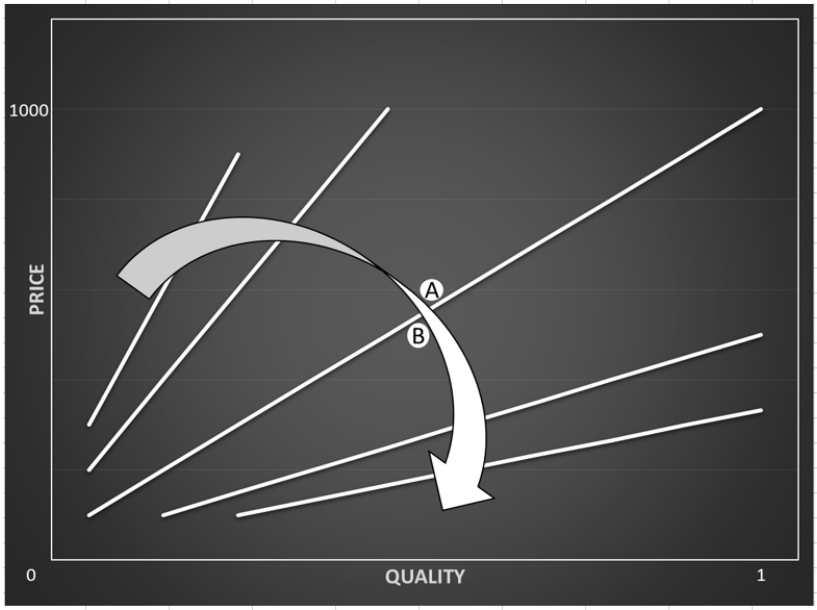

Figure 1 shows two bids: bid A and bid B.
The direction for better performance determines which bid has a better score.
In this case this will be bid B.

Figure 2, the direction for better performance. With Qbest = 1 and Pbest = 100

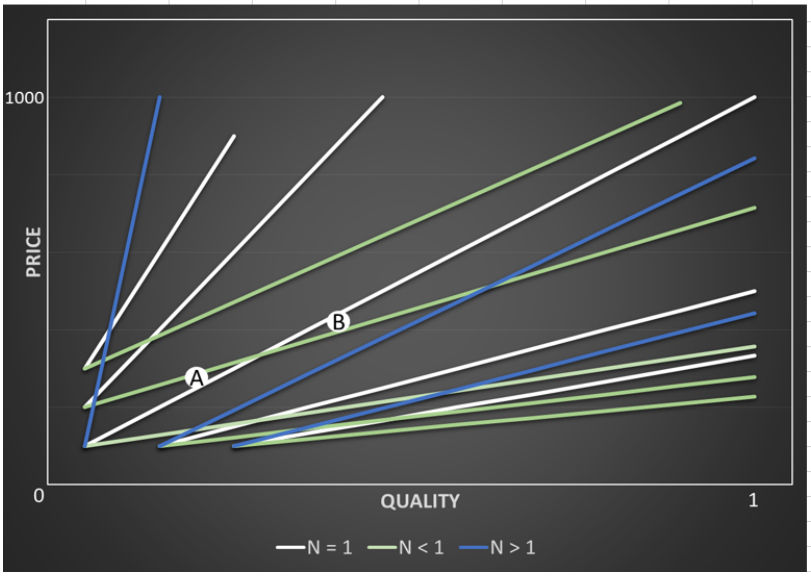

Figure 2 shows two bids: bid A and bid B.
The parameter N influences the direction for better performance and thus also the score of bid A and bid B.
If parameter N < 1 then bid A will be better than bid B.
If parameter N = 1 then bid B will be better than bid A.

Figure 11 graphical representation of the NX Utility index in the support system[12]

[12] The graphical representations of the other award mechanisms are made in the same way.

6.4 Calculation model to choose the most promising bid

As described in *6.1 How is the support system developed*, the support system has for every award mechanism a calculation model to calculate the score of the various bids the supplier could provide. See Figure 12 and Figure 13 for the calculation model of the NX Utility Index in the support system.

The yellow cells indicate what the supplier must fill in. And that is the weight of quality (predefined by the buyer), the costs to score 0-10 points for every sub-criterion of quality, the score on every sub-criterion of quality of bid *i*, the minimum margin of profit, the price of bid *i*, the estimation of the best quality and the estimation of the best price. When this is filled in, the NX Ui score, the price deficit and the Best Buy price will be automatically calculated. The best bid will be coloured green.

The score of the quality is often determined by several sub-criteria of quality. Therefore, there is the possibility for the supplier to fill in their score per sub-criteria of quality for a minimum of one and a maximum of five sub-criteria for quality.

It is possible for the supplier to fill in their costs to score 0-10 points for every sub-criterion of quality and the minimum margin of profit. The purpose of this is that the minimum price (P_i) can be calculated to reach the minimum margin of profit. In this case the score of quality, the costs to reach the score of quality and the minimum margin of profit are known. Minimum price to reach the minimum margin of profit and the score of the quality can be used to finally calculate the score of the bid.[13] The formulas of the margin of profit and the minimum price to reach the minimum margin of profit can be found in Appendix E. *Margin of profit*.

Sometimes a supplier wants to compare the score of the bids with a different Q_{best} (best quality) and P_{best} (best price). Because of this, it is possible to fill in a Q_{best} and P_{best} for bid i_a and for bid i_b. The supplier is now able to see if the ranking changes when the Q_{best} or P_{best} changes. To be able to estimate the Q_{best} and P_{best} the supplier could use historical data of competitors. It is important to mention that Q_{best} and P_{best} cannot be certain and that it stays an estimation.

Furthermore, there is a graphical representation of the various bids. It gives the supplier a better picture of the various bids and can compare them to each other. On the x-axis is the quality. This is determined by the quality of bid *i*. On the y-axis is the price. This is determined by the price of bid *i*.

The purpose of the calculation model is to finally choose the most promising bid the supplier should provide.

[13] It is also possible for the supplier to calculate the score of a bid with only the score of quality and an already determined price.

Calculation model of the NX Ui

= Need to be filled in by the supplier itself
= The most promising bid
= Important information

If you want to use the cost structure and your minimum margin of profit to choose the most promising bid, you have to fill in all the yellow cells.
It is also possible to choose the most promising bid based on your score of quality and an already determined price.
Then you have to fill in all the yellow cells except in Table 1 and the margin of profit. You do not have to use Table 3.

WQ =	0,5	The weight of the quality and the price is predefined by the buyer.
WP =	0,5	The weight of the quality and the price is together always 1
N =	1	

The score of the quality is often determined by several sub-criteria of the quality.
That is why there is Qi1 to Qi5. It is possible to use less than 5 sub-criteria.
Fill in the table below the estimated costs per sub-criteria to be able to score 0-10 points.

	0	1	2	3	4	5	6	7	8	9	10
Qi1	€ 500,00	€ 600,00	€ 700,00	€ 800,00	€ 900,00	€ 1.000,00	€ 1.100,00	€ 1.200,00	€ 1.300,00	€ 1.400,00	€ 1.500,00
Qi2	€ 1.500,00	€ 1.550,00	€ 1.600,00	€ 1.650,00	€ 1.700,00	€ 1.750,00	€ 1.800,00	€ 1.850,00	€ 1.900,00	€ 1.950,00	€ 2.000,00
Qi3	€ 180,00	€ 360,00	€ 540,00	€ 720,00	€ 900,00	€ 1.080,00	€ 1.260,00	€ 1.440,00	€ 1.620,00	€ 1.800,00	€ 1.980,00
Qi4	€ 110,00	€ 130,00	€ 170,00	€ 250,00	€ 410,00	€ 730,00	€ 890,00	€ 970,00	€ 1.010,00	€ 1.030,00	€ 1.040,00
Qi5	€ -	€ 10,00	€ 30,00	€ 60,00	€ 100,00	€ 150,00	€ 210,00	€ 330,00	€ 570,00	€ 1.050,00	€ 2.010,00

Table 1

Look at Figure 3, determine per bid and per sub--criterion of the quality a grade between 0 and 10 in the table below.
It is possible to fill in 1 to 10 bids.

	Bid 1	Bid 2	Bid 3	Bid 4	Bid 5	Bid 6	Bid 7	Bid 8	Bid 9	Bid 10
Qi1 =	7	6	5	6	8	4	9	5	8	8
Qi2 =	6	5	7	7	7	6	6	3	9	6
Qi3 =	5	5	6	6	6	4	8	3	8	7
Qi4 =	6	6	7	7	7	5	8	6	7	8
Qi5 =	6	6	6	6	6	5	8	5	8	8

Table 2

Determine the minimum margin of profit = 50%

	Bid 1	Bid 2	Bid 3	Bid 4	Bid 5	Bid 6	Bid 7	Bid 8	Bid 9	Bid 10
Cost of Qi1	€ 1.200,00	€ 1.100,00	€ 1.000,00	€ 1.100,00	€ 1.300,00	€ 900,00	€ 1.400,00	€ 1.000,00	€ 1.300,00	€ 1.300,00
Cost of Qi2	€ 1.800,00	€ 1.750,00	€ 1.850,00	€ 1.850,00	€ 1.850,00	€ 1.800,00	€ 1.800,00	€ 1.650,00	€ 1.950,00	€ 1.800,00
Cost of Qi3	€ 1.080,00	€ 1.080,00	€ 1.260,00	€ 1.260,00	€ 1.260,00	€ 900,00	€ 1.620,00	€ 720,00	€ 1.620,00	€ 1.440,00
Cost of Qi4	€ 890,00	€ 890,00	€ 970,00	€ 970,00	€ 970,00	€ 730,00	€ 1.010,00	€ 890,00	€ 970,00	€ 1.010,00
Cost of Qi5	€ 210,00	€ 210,00	€ 210,00	€ 210,00	€ 210,00	€ 150,00	€ 570,00	€ 150,00	€ 570,00	€ 570,00
Cost of Qi	**€ 5.180,00**	**€ 5.030,00**	**€ 5.290,00**	**€ 5.390,00**	**€ 5.590,00**	**€ 4.480,00**	**€ 6.400,00**	**€ 4.410,00**	**€ 6.410,00**	**€ 6.120,00**
Pi to reach minimum margin of profit	**€ 10.360,00**	**€ 10.060,00**	**€ 10.580,00**	**€ 10.780,00**	**€ 11.180,00**	**€ 8.960,00**	**€ 12.800,00**	**€ 8.820,00**	**€ 12.820,00**	**€ 12.240,00**

Table 3

Fill in per bid the price (Pi) in the table below.
The Pi can be based on the Pi determined in the table above. We recommend to use this Pi if you want to reach the minimimum margin of profit.
Look at Figure 4 to see the various bids and to be abe to compare them.

Qi =	0,6	0,56	0,62	0,64	0,68	0,48	0,78	0,44	0,8	0,74
Pi =	€ 10.360,00	€ 10.060,00	€ 10.580,00	€ 10.780,00	€ 11.180,00	€ 8.960,00	€ 12.800,00	€ 8.820,00	€ 12.820,00	€ 12.240,00

Table 4

Estimate the Qbest and Pbest.

A Qbest =	0,8		Estimate the value of the best (highest) quality. This has to be between 0 and 1
A Pbest =	€ 9.000,00		Estimate the value of the best (lowest) price.

	Bid 1a	Bid 2a	Bid 3a	Bid 4a	Bid 5a	Bid 6a	Bid 7a	Bid 8a	Bid 9a	Bid 10a
NX UI score	0,694980695	0,679920477	0,697542533	0,701298701	0,708407871	0,683035714	0,6890625	0,653061224	0,702028081	0,691176471
Price dificit	€ 196,36	€ 404,55	€ 162,27	€ 108,18	€ -	€ 320,91	€ 349,55	€ 689,09	€ 115,45	€ 297,73
Best buy	€ 10.163,64	€ 9.655,45	€ 10.417,73	€ 10.671,82	€ 11.180,00	€ 8.639,09	€ 12.450,45	€ 8.130,91	€ 12.704,55	€ 11.942,27

Table 5

NX UI best 0,708407871

To be able to compare the scores of the bids with a different Qbest and Pbest, it is possible to fill in a second Qbest en Pbest below.

B Qbest =	0,9		Estimate the value of the best (highest) quality. This has to be between 0 and 1
B Pbest =	€ 8.000,00		Estimate the value of the best (lowest) price.

	Bid 1b	Bid 2b	Bid 3b	Bid 4b	Bid 5b	Bid 6b	Bid 7b	Bid 8b	Bid 9b	Bid 10b
NX UI score	0,540540541	0,524850895	0,544423440	0,549165121	0,558139535	0,517857143	0,550000000	0,489795918	0,56162246	0,549019608
Price dificit	€ 388,89	€ 658,67	€ 324,00	€ 239,11	€ 69,33	€ 698,22	€ 264,89	€ 1.128,00	€ -	€ 274,67
Best buy	€ 9.971,11	€ 9.401,33	€ 10.256,00	€ 10.540,89	€ 11.110,67	€ 8.261,78	€ 12.535,11	€ 7.692,00	€ 12.820,00	€ 11.965,33

Table 6

NX UI best 0,561622465

Figure 12 calculation model of the NX Utility index in the support system[14]

[14] The calculation models of the other award mechanisms are made in the same way.

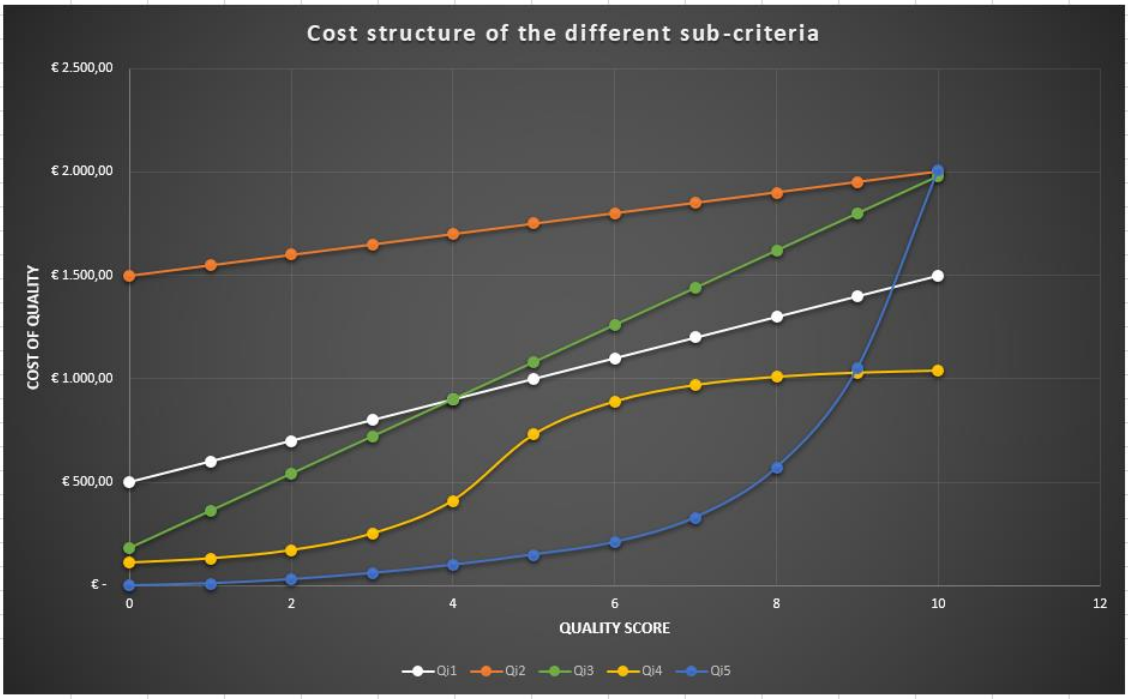

Figure 3

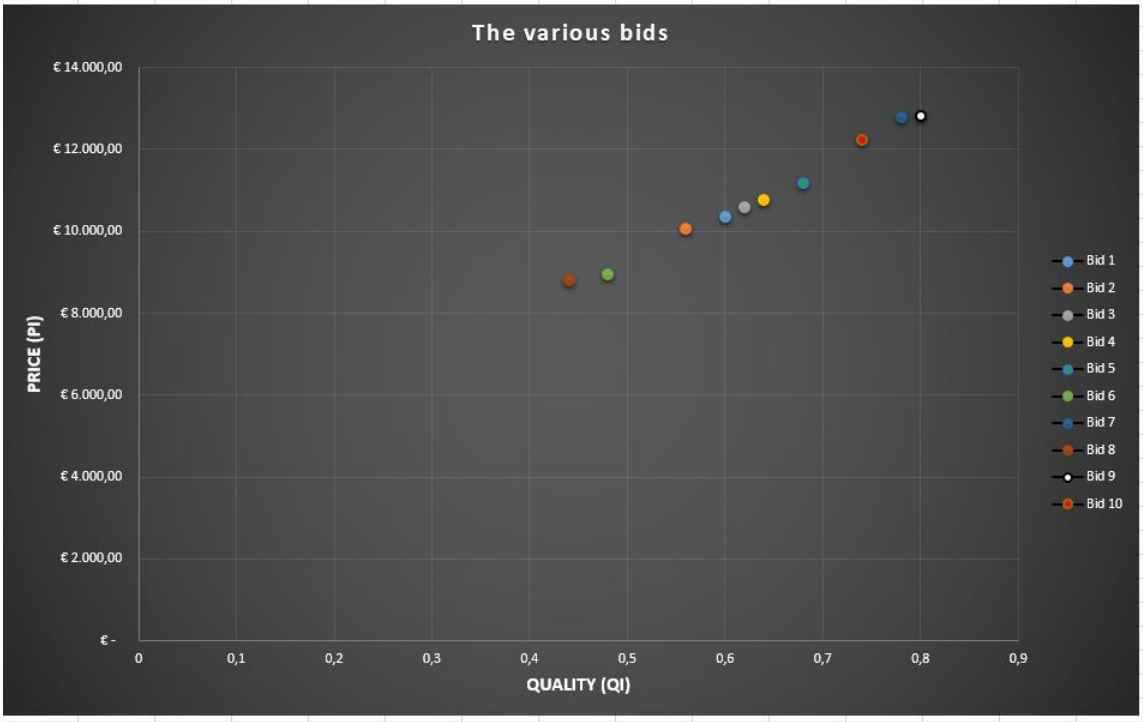

Figure 4

Figure 13 the graphs used for the calculation model of the NX Utility index in the support system

7. Conclusion and discussion

In this chapter the main research questions will be answered and we will construct a conclusion. Based on the conclusion we will discuss the recommendations for Negometrix and recommendations for further research.

7.1 Conclusion

The goal of this research is to get an answer to the research question: 'How to design a support system of the various award mechanisms in a way that the supplier knows which bid will be most promising?'

First, the research about the working of the award mechanisms showed that it is important for the suppliers to know the direction for better performance, because then the suppliers have an indication in which direction they have to look at, to find the most promising bid. Also, it is important for the suppliers to know the value of the parameters used in the formulas of the award mechanisms, because the parameters influence the direction for better performance.

When the award mechanisms are compared, it is clear that the direction for better performance for the various award mechanisms are very different. As a result, it is very important for the supplier to know which award mechanism is used and how this award mechanism works, because than the supplier can adjust their bidding behaviour to be able to provide their most promising bid.

The NX Utility index and the Low Bid Scoring formula are relative scoring methods. The Weighted Factor Method is an absolute scoring method. The difference is that a relative scoring method depends often on the best price and/or best quality. The best price and quality are uncertain and can only be estimated. Because of this, it is possible that suppliers may unintentionally provide a non-optimal bid. As a result, it is important to develop a good support system to help them optimise their bid.

Secondly, interviews showed that that the main focus of the suppliers to choose the most promising bid is on the weight of the quality and price. The weight of quality and price influence the direction for better performance and are important factors to be able to optimise a bid. One supplier thinks that it is sometimes difficult to determine the weight of the quality and price, because not every award mechanism is transparent. Also, the interviews showed that suppliers want a good explanation of the various award mechanisms and want a good support to be able to compare various options.

And last, after we researched how suppliers have to choose their most promising bid, we came up with a support system that consist out of an explanation of the award mechanisms (algebra, prose), a graphical representation of the award mechanisms and a calculation model to calculate the score of the bids. We developed the support system based on these components. To be able to develop these components and to meet the expectations of Negometrix and suppliers, we used the information found in the first and the second part of the research.

The best way to support the supplier in choosing his most promising bid is to combine every component of the support system. First the supplier has to seek the direction he has to look at, to find his most promising bid. This can be done with the help of the explanation and the graphical explanation of the award mechanisms. After that, the score of the remaining alternatives can be calculated with the calculation model.

7.2 Discussion

This research is a good start for supporting suppliers in making the decision which bid they should provide to increase their probability of winning the tender.

When suppliers are optimising their bid it is important to know the working of the award mechanism. The different variables in the formulas of the award mechanisms can influence the direction for better performance. It is clear that suppliers want to know how important quality and price is, to be able to optimise their bid. Therefore they should not only look at the weight of the price and quality, but also at the other variables. If the direction for better performance changes by a variable than the importance of price and quality changes with it. That is why we implemented the influence of all the variables in the support system.

There is a support system developed that consist out of different components. The explanation about the about the award mechanisms and the graphical explanation of the award mechanisms helps the supplier to determine in which direction they have to look at, to find the most promising bid. To be able to calculate the score of every alternative, a calculation model of the award mechanisms is developed. This is the final step for deciding which bid is the most promising one.

However, many improvements can still be made. For example, this research only elaborates on the NX Utility index, the Weighted Factor Method and the Low Bid Scoring formula. In practise there are more award mechanisms. This means that future research should also focus on other award mechanisms. In this way the support system is not only restricted to the suppliers using the software of Negometrix and can be shared on the entire market.

To be able to improve the support system and to know what the advantages and disadvantages of the support system are, the support system should be tested and criticized by suppliers. To verify if the support system is understandable for the suppliers, the suppliers should use the support system without any extra explanations about how the support system works. The suppliers should be asked to provide feedback about the support system, which can be used for further improvements.

Despite of the many improvements that still can be made, we recommend Negometrix to implement the support system in their software. The support system helps the supplier to put forward a better score and this is also positive for the buyer, because he gets an offer with also a higher score. This can improve the economic situation in terms of competition for Negometrix.

In the end, this thesis makes a good start towards fully supporting suppliers in choosing the bid with the highest probability of winning the tender. However, it will take time to do more research and to be able to improve this support system in a way that every supplier in the world can use it.

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Appendices

A. The influence of the parameters on the NX Utility index

In Section 3.2 *NX Utility index*, we discuss the working of the formula of the NX Utility index (NX Ui). In this formula are various parameters. These parameters can change the direction for better performance. In this section we will discuss the influence per parameter.

Figure 14 shows the influence of factor N on the direction for better performance when the formula of the NX Ui is used. The bids with the same outcome are on the same line. The N is a factor that is used to indicate the weight of the price and the quality.[15] When N > 1 with the same price range and quality range the lines are steeper, in this case quality is more important than price. When N < 1 with the same price range and quality range the lines are more horizontal, in this case the price is more important than the quality.

A different weight for the price and the quality can have a different outcome in the tender. See bid A and bid B in Figure 14. If quality and price have the same weight, N = 1, bid B wins. If quality has a lower weight than price, N < 1, bid A wins. It is important for suppliers to closely look at the weight of quality and price, because it can have a great influence on the score of the bid and can help them to optimise their bid.

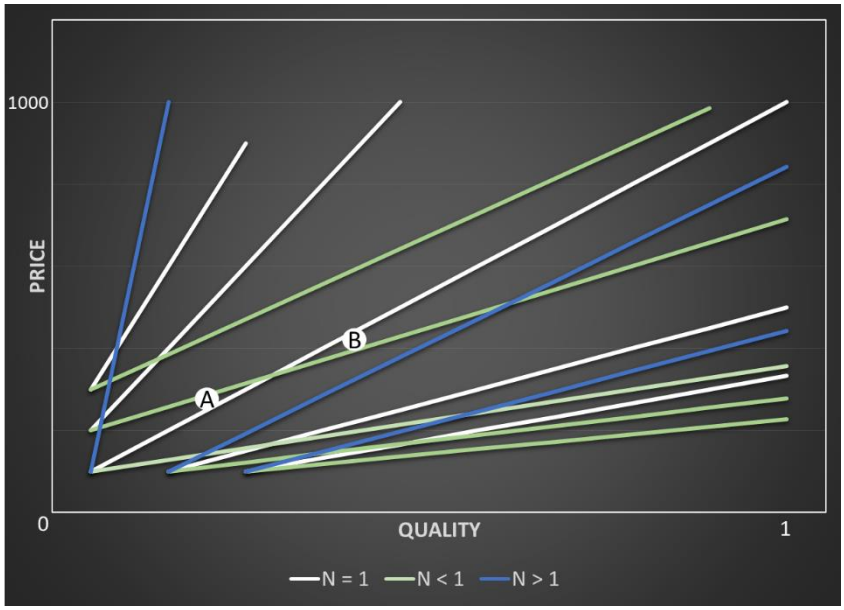


Figure 14 direction for better performance with various sizes of the factor N for the NX utility index.[16]

The best price and quality can also influence the direction for better performance when the formula of the NX Ui is used. Award mechanisms with P_{best} and/or Q_{best} in their formula are relative and can lead to rank reversal. P_{best} and Q_{best} are not determined by the buyer, but depends on the bids that are provided by every supplier. That means that P_{best} and Q_{best} are known only after the deadline of the tender. Because of this, suppliers do not know what the value of P_{best} and Q_{best} are and only can make assumptions.

[15] The purpose of factor N is discussed in Section 3.2 NX *Utility index*.

[16] The outcomes of this graph are calculated with formula of the NX Ui. The price range is from 100 to 1000 and the quality range from 0 to 1. The bids with the same outcome are on the same line.

Figure 15 shows the direction for better performance when there are various P_{best} and Q_{best}. It can be seen that the direction for better performance changes as P_{best} and Q_{best} change. This may result in a rank reversal. See bids A and B in the graph. Suppose P_{best} is 100 euros and Q_{best} is 1 then bid A will win, but when P_{best} is 300 euros and Q_{best} is 0,8 then bid B will win. How higher the P_{best} and lower the Q_{best} how more horizontal the lines in Figure 15 are. This means that the price will be more important.

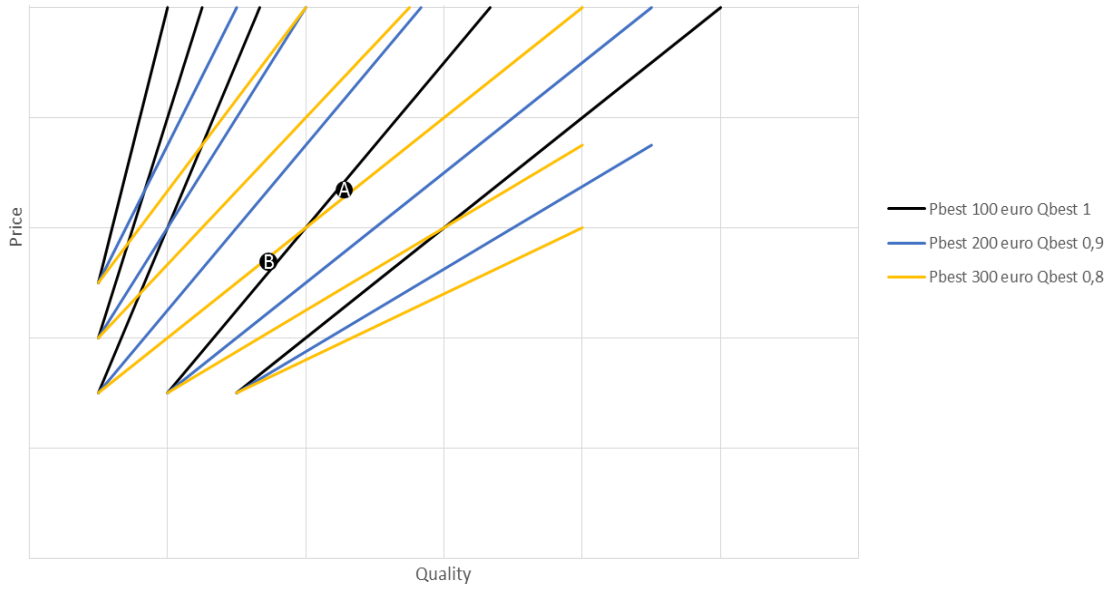


Figure 15 direction for better performance with various best prices and qualities for the NX Utility index. This is calculated with the factor N set as 1.[17]

[17] The outcomes of this graph are calculated with formula of the NX Ui. The price range is from 100 to 1000 and the quality range from 0 to 1. The bids with the same outcome are on the same line.

B. The influence of the parameters on the Weighted Factor Method

In Section 3.3 *Weighted Factor Method*, we discuss the working of the formula of the Weighted Factor Method (WFM). In this formula are various parameters. These parameters can change the direction for better performance. In this section we will discuss the influence per parameter.

The price range is determined before the tender is published. It is only an assumption of the buyer what this range should be. To be able to determine this range the buyer has to have knowledge about the market. The range of the price has an influence on the outcome of the tender, see Figure 16. How wider the range how steeper the lines and quality will be more important. If the range is smaller the lines are more horizontal and price will be more important.

The direction for better performance changes if the size of the price range becomes smaller or bigger. Elaborate on bid A and B in Figure 16, it shows that if the price range is 0 to 600 euro bid A wins. If the price range is 0 to 1000 euro bid B wins. This variable is set by the buyer. As a result, the supplier can take this into account when he optimises his bid.

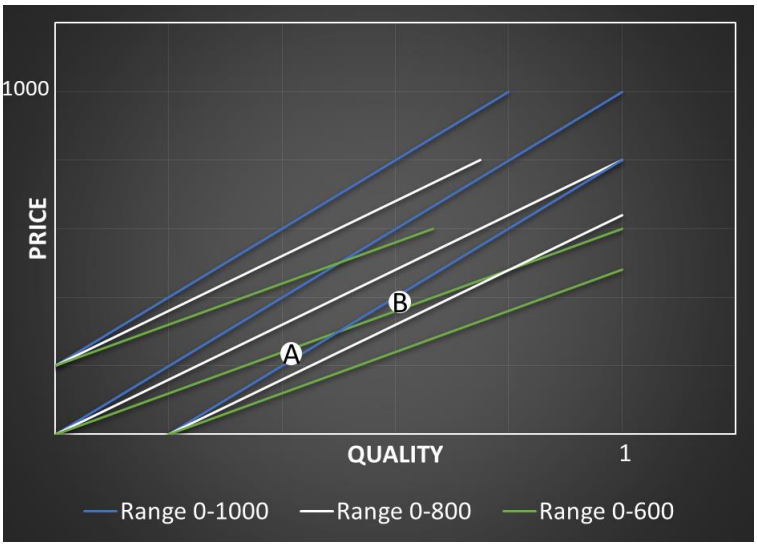


Figure 16 direction for better performance with various price ranges for the WFM.[18]

However, if the range stays the same, but the P_{setmax} and the P_{setmin} changes it will have no influence on the outcome of the ranking of the tender. For example:

Option 1: WQ = 0,5 en WP = 0,5
$P_{setmax} = 800$ en $P_{setmin} = 0$
Quality range from 0 to 1

Option 2: WQ = 0,5 en WP = 0,5
$P_{setmax} = 1000$ en $P_{setmin} = 200$
Quality range from 0 to 1

By option 1 and 2 is the range the same, it is 800, but the P_{setmax} at option 1 and 2 are different, the same applies to the P_{setmin}. See Figure 17 for the outcome of option 1 and 2, the direction for better performance is the same because the lines of option 1 and 2 are parallel to each other. That means that the result of the ranking remains the same when the price range stays the same.

[18] The outcomes of this graph are calculated with the formula of the WFM. The quality range is from 0 to 1 and WP=WQ.

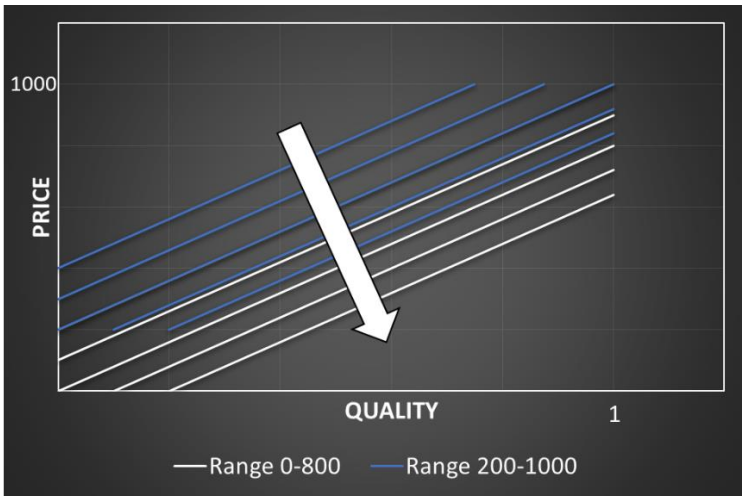


Figure 17 direction for better performance with the same size for the price range but various minimum and maximum for the WFM[19]

Also the weight of the price and the quality influence the direction for better performance for the WFM. Figure 18 shows what the direction for better performance is for various weight in price and quality. When WP = 0,4 and WQ = 0,6 with the same price range and quality range the lines are steeper, in this case quality is more important than price. When WP = 0,6 and WQ = 0,4 with the same price range and quality range the lines are more horizontal, in this case the price is more important than the quality.

A bid has different scores for different weights of price and quality. When WP = WQ bid B would win, but when WP = 0,6 and WQ = 0,4 bid A would win. As a result it is important for the supplier to know what the weight of the price and the quality is, because the score of one bid could change when there is a different weight for price and quality.

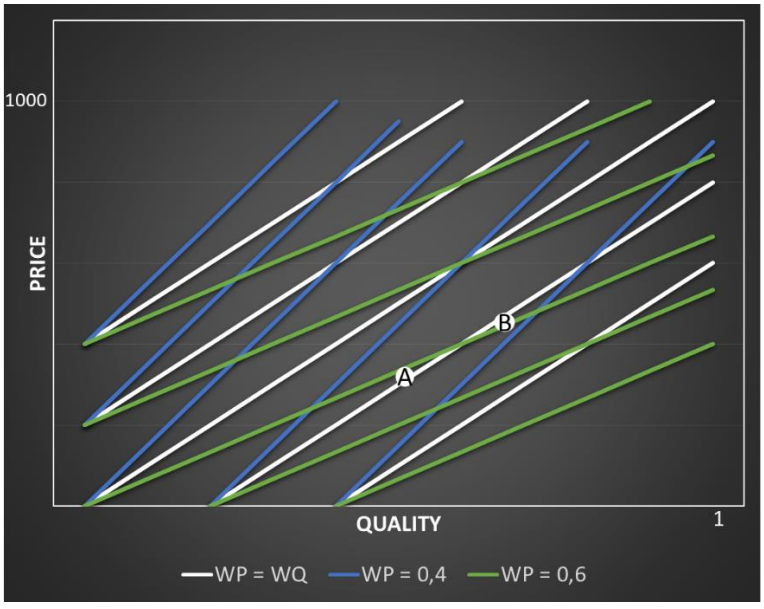


Figure 18 direction for better performance with various weight of the price and the quality for the WFM[20]

[19] The outcomes of this graph are calculated with the formula of the WFM. The quality range is from 0 to 1 and WP=WQ.
[20] The outcomes of this graph are calculated with the formula of the WFM. The price range is from 0 to 1000 and the quality range from 0 to 1. P_{setmax} is determined as 1000 and P_{setmin} is determined as 0. The bids with the same outcome are on the same line.

C. The influence of the parameters on the Low Bid Scoring formula

In Section 3.4 *Low Bid Scoring formula*, we discuss the working of the Low Bid Scoring (LBS) formula. In this formula are various parameters. These parameters can change the direction for better performance. In this section we will discuss the influence per parameter.

Figure 19 shows what the direction for better performance is for various weight in price and quality. When WP = 0,4 and WQ = 0,6 with the same price range and quality range the lines are steeper, in this case quality is more important than price. When WP = 0,6 and WQ = 0,4 with the same price range and quality range the lines are more horizontal, in this case the price is more important than the quality.

As described in, 3.2 NX Utility index can a bid have a different score if the weight for the price and the weight for the quality changes. This can change the ranking of the tender. This also applies to the weighted factor method. When WP = WQ bid B would win, but when WP = 0,6 and WQ = 0,4 bid A would win. As a result it is important for the supplier to know what the weight of the price and the quality is, because the score of one bid could change when there is a different weight for price and quality.

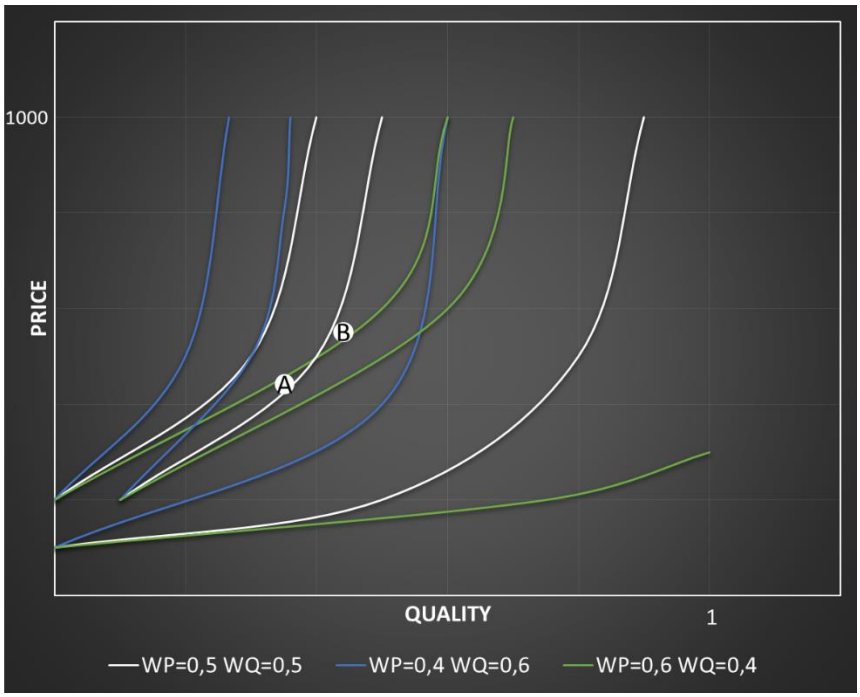


Figure 19 direction for better performance for the low bid scoring formula if the weight of the price and the quality changes.[21]

[21] The outcomes of this graph are calculated with the LBS formula. The price range is from 100 to 1000 and the quality range from 0 to 1. The bids with the same outcome are on the same line.

Also the P_{best} can influence the direction for better performance for the Low Bid Scoring method. Award mechanisms with P_{best} and/or Q_{best} in their formula are relative and can lead to rank reversal. P_{best} is not determined by the buyer, but depends on the bids that are made by the suppliers. That means that P_{best} is known only after the deadline of the tender. Because of this, suppliers do not know what the value of P_{best} is and only can make assumptions.

Figure 20 shows the direction for better performance when there are various P_{best}. It can be seen that the direction for better performance changes as P_{best} change. This may result in a rank reversal. See bids A and B in the graph. If P_{best} is 100 euros then bid B will win, but when P_{best} is 200 euros then bid A will win. How higher the P_{best} how more horizontal the lines in Figure 20 are. This means that the price will be more important.

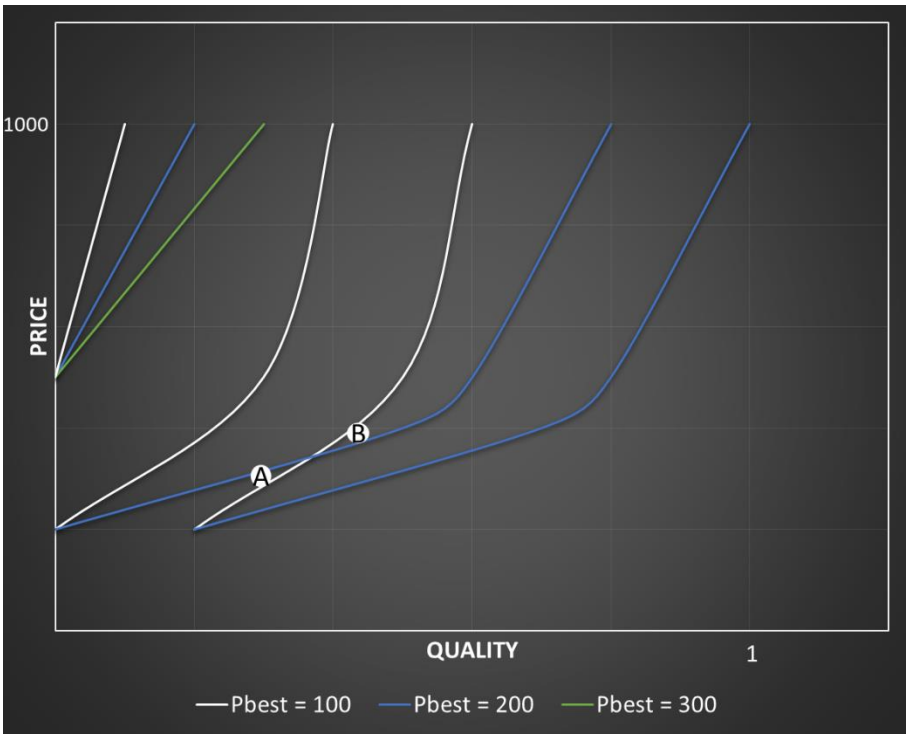
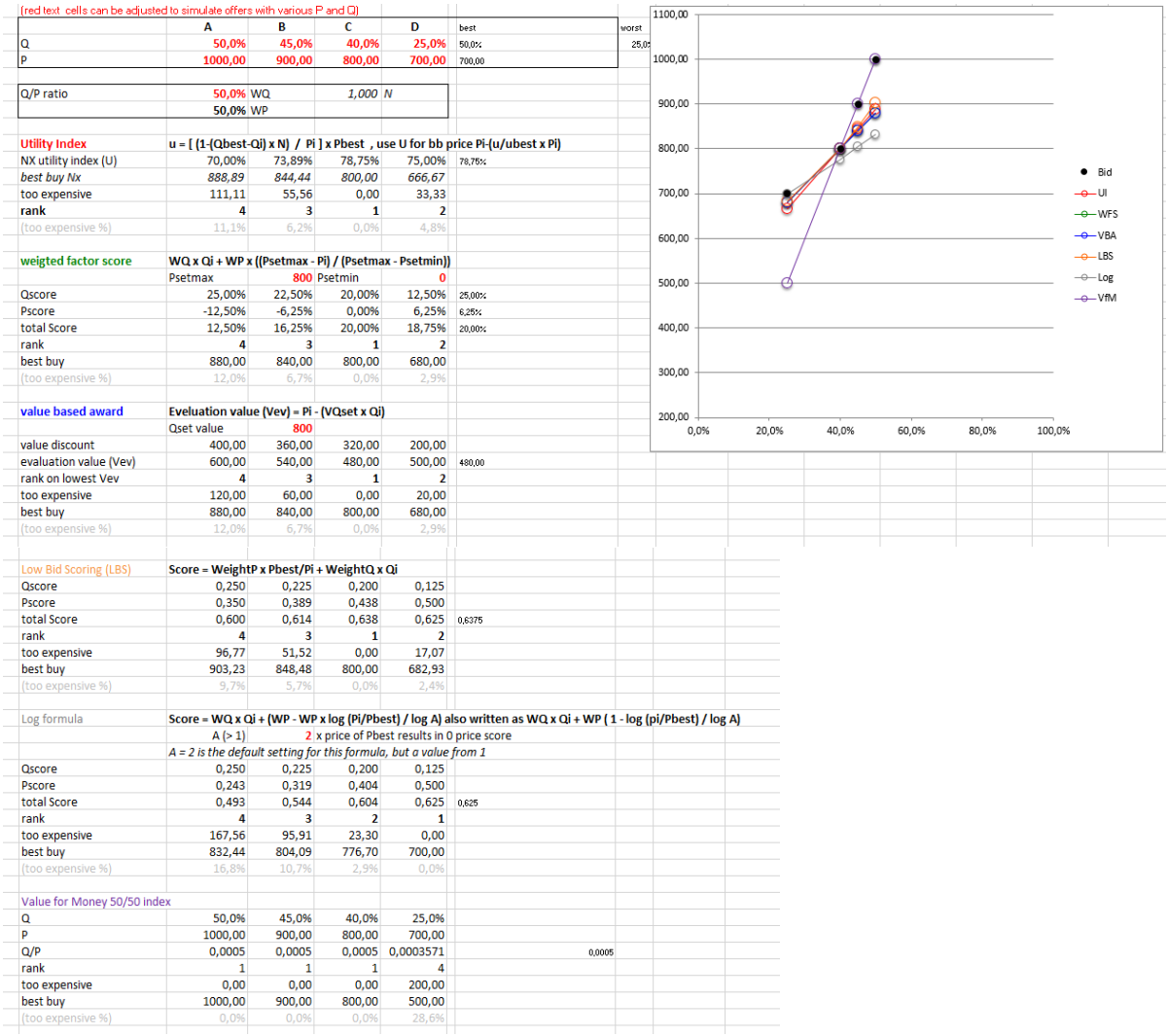


Figure 20 direction for better performance for the low bid scoring formula if the best price changes.[22]

[22] The outcomes of this graph are calculated with the LBS formula. The price range is from 100 to 1000 and the quality range from 0 to 1. The bids with the same outcome are on the same line.

D. Calculation sheet of Negometrix

See Figure 21, this is a calculation sheet of the various award mechanisms that Negometrix offers as support for buyers (Negometrix, *Rekensheet gunningsformules Negometrix,* 2018)



(red text cells can be adjusted to simulate offers with various P and Q)

	A	B	C	D	best	worst
Q	50,0%	45,0%	40,0%	25,0%	50,0%	25,0%
P	1000,00	900,00	800,00	700,00	700,00	

Q/P ratio	50,0%	WQ	1,000 N
	50,0%	WP	

Utility Index	u = [(1-(Qbest-Qi) x N) / Pi] x Pbest , use U for bb price Pi-(u/ubest x Pi)				
NX utility index (U)	70,00%	73,89%	78,75%	75,00%	78,75%
best buy Nx	*888,89*	*844,44*	*800,00*	*666,67*	
too expensive	111,11	55,56	0,00	33,33	
rank	**4**	**3**	**1**	**2**	
(too expensive %)	11,1%	6,2%	0,0%	4,8%	

weigted factor score	WQ x Qi + WP x ((Psetmax - Pi) / (Psetmax - Psetmin))				
	Psetmax	800	Psetmin	0	
Qscore	25,00%	22,50%	20,00%	12,50%	25,00%
Pscore	-12,50%	-6,25%	0,00%	6,25%	6,25%
total Score	12,50%	16,25%	20,00%	18,75%	20,00%
rank	**4**	**3**	**1**	**2**	
best buy	880,00	840,00	800,00	680,00	
(too expensive %)	12,0%	6,7%	0,0%	2,9%	

value based award	Eveluation value (Vev) = Pi - (VQset x Qi)				
	Qset value	800			
value discount	400,00	360,00	320,00	200,00	
evaluation value (Vev)	600,00	540,00	480,00	500,00	480,00
rank on lowest Vev	**4**	**3**	**1**	**2**	
too expensive	120,00	60,00	0,00	20,00	
best buy	880,00	840,00	800,00	680,00	
(too expensive %)	12,0%	6,7%	0,0%	2,9%	

Low Bid Scoring (LBS)	Score = WeightP x Pbest/Pi + WeightQ x Qi				
Qscore	0,250	0,225	0,200	0,125	
Pscore	0,350	0,389	0,438	0,500	
total Score	0,600	0,614	0,638	0,625	0,6375
rank	**4**	**3**	**1**	**2**	
too expensive	96,77	51,52	0,00	17,07	
best buy	903,23	848,48	800,00	682,93	
(too expensive %)	9,7%	5,7%	0,0%	2,4%	

Log formula	Score = WQ x Qi + (WP - WP x log (Pi/Pbest) / log A) also written as WQ x Qi + WP (1 - log (pi/Pbest) / log A)				
	A (> 1)	2	x price of Pbest results in 0 price score		
	A = 2 is the default setting for this formula, but a value from 1				
Qscore	0,250	0,225	0,200	0,125	
Pscore	0,243	0,319	0,404	0,500	
total Score	0,493	0,544	0,604	0,625	0,625
rank	**4**	**3**	**2**	**1**	
too expensive	167,56	95,91	23,30	0,00	
best buy	832,44	804,09	776,70	700,00	
(too expensive %)	16,8%	10,7%	2,9%	0,0%	

Value for Money 50/50 index					
Q	50,0%	45,0%	40,0%	25,0%	
P	1000,00	900,00	800,00	700,00	
Q/P	0,0005	0,0005	0,0005	0,0003571	0,0005
rank	1	1	1	4	
too expensive	0,00	0,00	0,00	200,00	
best buy	1000,00	900,00	800,00	500,00	
(too expensive %)	0,0%	0,0%	0,0%	28,6%	

Figure 21 calculation sheet of Negometrix of the various award mechanisms (Negometrix, Rekensheet gunningsformules Negometrix, 2018)

E. Margin of profit

The formula of the margin of profit is (Financieel InfoNu, 2018):

$$Margin\ of\ profit = \frac{profit}{total\ turnover} * 100\% \quad (8)$$

$$Profit\ =\ total\ turnover\ -\ the\ costs\ to\ reach\ 0\ to\ 10\ points\ for\ quality$$

Total turnover = the price of bid *i* (P_i)

To be able to calculate the minimum price the supplier has to ask for to reach the minimum margin of profit, we need to release the variable total turnover from the formula above. We show this below.

$$margin\ of\ profit = \frac{total\ turnover - costs}{total\ turnover}$$

$$margin\ of\ profit *\ \ total\ turnover =\ total\ turnover - costs$$

$$total\ turnover - (margin\ of\ profit *\ \ total\ turnover) =\ costs$$

$$(1 - margin\ of\ profit) * total\ turnover =\ costs$$

$$total\ turnover = \frac{costs}{(1 - margin\ of\ profit)} \quad (9)$$