OPTIMAL NUMBER OF TENDERS IN PRACTICE

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Abstract

In this paper we consider what is the current practice when a purchaser has to decide on the number of bids he wants to receive in a tender procedure. Furthermore we look to what extent a formal model, the so-called ETQ-model, together with a DSS can be useful in facilitating and improving that decision. The validity of the model assumptions is analyzed with empirical evidence from over thirty cases. Furthermore, a few interviews were conducted with tactical purchasers to gain insight into the practical applicability of the model and the DSS and identify specific directions for further improvement.

Keywords: competitive bidding, tendering, decision making

When to use competitive bidding?

Competitive bidding (or tendering) remains an important purchasing practice. With competitive bidding the market mechanism (competition between suppliers) is used to obtain the lowest price and/or best value for money. Both the private and the public sector make use of competitive bidding. Whereas for the first only the best value for money is important, for the latter also public accountability plays an important role (Holmes, 1995). In governmental agencies tendering procedures are often compulsory (GPA, directives on tendering in the European Union). These directives should provide public accountability and improve the effectiveness of purchasing and fair trade within (EU and other) marketplaces. This is done by setting up the tender procedures in such a way that all tenders are evaluated in a uniform way and that the contract is given to the supplier with the most economic bid (Smyth, 1997).

It is good to note the difference in tendering procedures between the public and private sector, because of this public accountability. In private firms often negotiations follow after the tender procedure to determine the final price (Leenders, Fearon, 1993), a practice that is often forbidden for governmental purchases. This makes it even more important for the public sector to arrange the tendering procedure as good as possible as no "damage control" can be done with extra negotiations afterwards.

When to apply competitive bidding? Clearly, when a situation exists that will prevent the market mechanism in some way, the outcome of a tendering procedure may not be optimal, making it therefore less applicable. This is the case when not enough possible suppliers (only a few or even one) are available. Also with a collusion of (some of) the bidders the competition element is destroyed. Knowing that this will occur just negotiating with a few suppliers would probably lead to the same outcome, but without the whole effort of setting up the whole tendering procedure (Holmes, 1995). Competitive bidding is also difficult when the specification of the product is not clear, making the comparison of tenders a difficult job and therefore more costly. Negotiations in this case can be more flexible and it could be better for developing trust between companies. This flexibility may also help to adapt new technology more quickly. From this it can be concluded that competitive bidding is especially useful for leverage (and to some extent) routine purchases in terms of the purchasing portfolio of Kraljic (Kraljic, 1983) .

The main reason that competitive bidding is limited however lies with the company (agency) that is doing the tendering procedure. Assuming a perfect market mechanism the lowest price will be achieved by requesting as many tenders as possible, because the level of the lowest bid will be lower on average as the number of bidders increases (Holt, 1979). The most important factor that is limiting this, is the costs involved with a tender procedure for the purchasing organisation (McMillan, 1998). These costs can be substantial and consist of costs that are fixed and costs that vary with the number of companies that are invited to tender. Fixed costs are mainly the costs of setting up the procedure, writing the request for quotations with the specifications and defining an evaluation procedure. The variable costs related to each bid are the costs associated with: handling queries, filing, reading and evaluating the tenders and informing the supplier of the outcome. Given the high complexity of some tenders the time spend on evaluation can be huge.

From the above we can conclude that in order to ensure a competitive bid the selection of possible suppliers must be numerous, qualified and reliable enough, but not more than necessary in view of the tendering costs involved with each extra bid (see also Leenders, Fearon,1993).

Insert figure 1 here

There is therefore a trade off between the best bid that can be expected and the tendering costs that are necessary to obtain it. Hence, there will be an optimal number of tenders that minimizes the total costs of the tendering process, i.e. the tendering costs together with the expected price that will be paid for the contract. Graphically this trade off is shown in Figure 1. Note that the purchaser implicitly controls these total costs to a certain extent by deciding at the beginning of the process on the number of tenders he wants to receive. For the latter part of the paper we will refer to the optimal number of tenders as the Economic Tender Quantity (ETQ, see De Boer, Van Dijkhuizen, Telgen, 2000).

Calculating the economic tender quantity (ETQ)

In order to be able to quantify the ETQ a formal decision model has been developed (De Boer, Van Dijkhuizen, Telgen, 2000 and earlier work by Lansdowne, 1996). We will now first discuss this model and its assumptions in order to be able to explain how the validity of the assumptions can be checked.

In the ETQ model assumptions are made on three areas: the bid evaluation, the suppliers and the tendering costs. First, considering the bid evaluation it is assumed that price is the only criterion, hence the bid with the lowest price will be awarded the contract. However all other criteria that can be translated into a price (like for instance the delivery time may be expressed as costs), can be included easily. This assumption is made for simplification reasons as the bid has to be compared with the tendering costs and it is more complicated to quantify the ETQ in a kind multi-criteria setting.

Each supplier is assumed to give an independent bid. Also all suppliers make a bid from the same probability distribution (for the rest of this paper referred to as the "bid distribution"). For instance when this probability distribution is uniform between 10 and 15, all suppliers give a random bid between those boundaries (and of course the lowest one will be awarded the contract). In practical terms a purchaser needs to have enough knowledge of the supply market to be able to estimate what bid prices can be expected.

Looking at the tendering costs the fixed costs are not relevant. Having decided to start a tendering procedure the fixed costs are not dependent on the number of bids (thus constant) and can therefore be omitted. The variable costs are assumed to be proportional with the number of tenders (every tender will take the same amount of time to evaluate).

Using these assumptions De Boer et al. (De Boer, Van Dijkhuizen, Telgen, 2000) showed that for a different types of bid distributions (in particular the uniform, triangular and normal probability distribution) the ETQ is uniquely determined by the parameters of that bid distribution and the costs per tender. An example of this is given in Figure 2. Here we assumed the bids have a normal distribution (μ,σ) and the bid spread as is used on the vertical axis in the graph is defined as the 2σ value on both sides, hence 4σ in total, which means about 95% of the bids will be within the bidspread defined in this way.

Insert figure 2 here

Having estimated the evaluation costs per tender and the two parameters of the normal distribution, with Figure 2, the ETQ can be obtained. Not that actually the ETQ is only dependent on the bid spread (thus σ) and the costs per tender and not on the mean of the normal distribution μ. De Boer et al. showed that this holds for all investigated distributions. In other words the optimal number of bids to be requested is not dependent on the average market price, but only on the expected spread in the market and on the evaluation costs. Based on this company rules like inviting at least X suppliers to tender above a certain threshold for the contract value have no rationality.

The validity of the ETQ model however depends on the validity of the assumptions. First of all, the suppliers each have to submit a bid independently. This assumption is of course very hard to check as no supplier will easily admit this not to be true officially taking into account the legal implications (anti-trust laws). Second, and this can be checked, which probability distributions for the bids actually occur in practice? To check this we send out a request to both public agencies and private companies for tender procedures where at least five tenders were received (in order to be able to conclude something about the bidspread the number of tenders should not be too low). More than 30 cases were received and the outcome will be discussed in the next section. Third, the evaluation costs were assumed to be proportional per tender. These costs mainly consist of the working hours spend by purchasers and therefore then these working hours must be estimated. In most companies not much data exists on these working hours. To gain more insight in the actual evaluation costs a few interviews with tactical purchasers were conducted. In these interviews also the practical applicability of the

ETQ model was tested. We will come back to that after the section about the results on the bid distributions.

Bid distributions in practice

In auctioning literature (e.g. Milgrom, 1989; Riley, 1989; Cripps, Ireland, 1994) the suppliers are always considered to act rationally and independently and submit a bid that will maximize their expected revenue. As the focus is on the bidder's side, the distribution that occurs for the buyer receiving a number of those bids is not considered. A phenomenon that can occur is the so-called "winner's curse": a situation where the supplier with the lowest bid, a bid that is much lower than the rest (and therefore is awarded the contract), estimated the costs too low (having misunderstood the information perhaps), leaving the winner with a non profitable contract and therefore it often leads to bad performance from his side (Milgrom, 1989; Beattie, Fearnley, 1998). When looking at the distribution of bids for one tendering procedure a few low bids (compared to the rest) extra could occur because of this. Also in a tendering procedure suppliers who do not really want that specific contract (having no capacity available at that moment for instance), but still want to show their interest (giving them more chance for similar contracts in the future), may submit higher, less competitive bids. Taking this effect together with the winner's curse into consideration the bid distribution could have long tails with low and high prices.

As mentioned in the previous section we send out a request for information about tender procedures, particular the ones where a considerable amount of bids were received. This request was send to various companies and public agencies in the Netherlands. We specifically asked for cases with at least five bids in order be able to at least estimate to a certain extent which bid probability distribution is applicable. The other condition was that the price had to be the dominant criterion in the tender procedure as other criteria are not taken into account in the ETQ model. As a result we received back over 30 cases that met those conditions.

The majority of these cases (about 70%) came from public agencies (municipalities, provinces, universities). The number of bids per case varied from 5 to 12. The price of the contracts varied from about 30,000 Euro to 50 million Euro as far as the prices were given. As we are only interested in the spread companies could also index the actual prices for confidentiality reasons.
The variety in the purchases was also high ranging from supplies like nitrogen gas, cars, chairs and PCs to services like cleaning and works like road construction and tunneling. Depending on the products, the different markets, the standard deviation in the bids (as a percentage) was also very different for each case, ranging from 2 % to 40 %. Another obvious result from the cases was that the spread of the bids for a large number of those cases was in a way similar: most bids are quite close to each other, whereas the highest and/or the lowest was very different from the rest.

Insert figure 3 here

Unfortunately even the highest number of bids per case we received, namely 12, is still a very small number to make a good fit of a probability distribution. However for this case (buying

PCs, the prices were indexed) a Q-Q plot (quantile-quantile graph) was made in order to look to what extent a normal distribution was applicable (see Figure 3). When a normal distribution applies to the bid data the points in the figure should fit in a straight line (y = A*x+B) where A (the slope) is equal to the σ of the normal distribution and B is equal to the mean μ. The linear fit in Figure 3 shows the actual data deviates a bit, but the number of points is too small to fit any distribution with high confidence (in other words to make reliable chi-squared tests).

We therefore had to take a more global view on the bid data. In order to be able to compare all cases better we indexed them all the same, dividing each bid value with the average of the case it belongs to (making the average bid 1 for all cases). After that from each bid value 1 was subtracted, making the average 0 instead of 1.

Insert figures 4 and 5 here

Assuming a normal distribution may be applicable for each case also the sum of all cases can be considered as the sum of two normal distributions with the same mean is itself a normal distribution again. In this way we have almost 200 data points. With these points we performed a symmetry check (see Figure 4) and we made a Q-Q plot in order to check whether the aggregation of all bid data could be fit with a normal distribution (see Figure 5). In figure 4 the bid data was divided into two, comparing the lowest with the highest value, the next lowest with the next highest and so on. Having a symmetric distribution and applying linear fitting would lead to a slope of that fit equal to –1. In this case the slope is more negative, indicating the upper tail of the distribution is wider than the lower tail (more excess in very high bids than in very low bids). Furthermore the Q-Q plot in Figure 5 indicates that the bid data can not be fit with a normal distribution. The right tail is clearly above the linear fit, whereas the left tail is below. This indicates a probability distribution with a bigger probability density for the tails would give a better fit. Note that for the triangular and uniform distribution this probability density of the tails is even less than for the normal distribution, making them therefore (compared to the normal distribution) even less applicable. Distributions that assign a bigger probability distribution to the tails are Student t-distributions. The ETQ-model has not been checked for these distributions yet though and obviously this would be a good thing to do in the immediate future as the empirical evidence suggests using t-distributions. Looking back to the beginning of this section the evidence we found for wide distributions seems to support the ideas about the winner's curse and having a few non competitive high bids extra.

Use the ETQ model in practice: developing and testing a DSS

For practical application we developed a prototype decision support system (DSS) of the ETQ-model. We expected the DSS to aid the user of the ETQ-model by presenting the input parameters in a clear way, performing all necessary calculations automatically and presenting the results graphically. A screenshot of this DSS can be seen in Figure 6. To be able to use the DSS a purchaser will need to have enough information about the market to be able to estimate what bid prices can be expected (and thus what kind of distribution) . Furthermore he needs to have an idea on the time (costs) that will be involved with each tender. Based on this input the

ETQ together with the outcome of the total costs are calculated. Naturally the better the input can be estimated the more accurate the predicted outcome will be.

Insert figure 6 here

With this DSS available we conducted a couple of interviews with tactical purchasers of a small number of companies and public agencies to use the DSS in their practice. The main goal was to test to what extent the tool (and also the model behind it) was indeed considered useful and how it could be improved.

For these interviews we formulated a testing protocol in order to cover all aspects in an organised way within an hour (and therefore it was not needed to ask for too much time of the purchasers increasing the number of people willing / able to cooperate). The testing protocol consisted of five items: asking for a brief overview of the company, the role of purchasing and the position of the interviewed in this, explanation of the ETQ-model, explanation of the DSS with an example, trying out the DSS with cases from practice of the interviewed person and finally an evaluation by means of a small questionnaire. Here we will briefly present and discuss the results of two interviews.

The first interview was held with a Purchasing manager (manager A) in a global manufacturer of clothing and shoes. A is working in a subsidiary in the Netherlands. The purchasing department she is working in has only recently been created and hence few to none procedures exist. When asked for a general opinion, she indicated that the ETQ-DSS would not be particularly relevant for her. Tender quantity decisions were based on intuition and were not perceived as specifically difficult. As a rule of thumb, 5 to 6 suppliers would be normally be invited of which usually 2 to 3 could be discarded right away. The ETQ-DSS was applied to a case A had recently been involved in. This case concerned the selection of a supplier of business cards and stationery. A clearly indicated that it would have been very difficult for her to estimate the bidspread for this case. She did not have experience with purchasing this particular item, nor did she know anyone within the company who had such experience. Furthermore, relying on experience from previous positions in other companies would have been difficult because the particular characteristics of the required items were different. A had initially approached six potential suppliers but this was merely to assess their technical capability and willingness to supply. Out of these suppliers, three were asked to submit a bid. Based on the bids received and A's estimate of the variable evaluation costs, we used the ETQ-DSS to determine the ETQ for this case. The result confirmed the decision to ask three suppliers.

The second interview was held with a purchasing manager (manager B) in a large Dutch bank. B is primarily concerned with supporting the purchasing of temporary labor. In B's organization a formal procedure prescribed to at least ask for two quotes in case of projects exceeding a predefined financial threshold. The ETQ-DSS was applied to the case of outsourcing certain research work. In B's organization, one department would normally conduct this research but an expected increase in the demand for this research had brought up the question whether or not B's organization should use outside specialist suppliers to conduct the more operational aspects of this research. In that respect, the case concerned a make-or-buy investigation. Initially eight suppliers were asked to quote. B indicated that by only briefly talking to a few suppliers the insight had emerged that relatively large price differences were present on the market. Moreover, as the bank was already conducting some of this research in-house, B had a clear point of reference. However, from the 8 suppliers that were approached, B only continued with a subset of them. A limited number of suppliers could be discarded more or less immediately. Based on the received bids and B's estimate of the variable cost of evaluation, we used the ETQ-DSS to determine the ETQ for this case. Again, the outcome was close to the number of suppliers that B had worked with more intensively. B indicated that the ETQ-DSS could prove to be useful in cases similar to the one tested here. However, B also mentioned the example of selecting suppliers for printed matter in which the organization will alternate between a limited set of known suppliers due to the required investments in tools. In that case B argued that the Tender Quantity decision would not be as problematic as compared to the outsourcing of research.

Based on the two interviews and experiments with the ETQ-DSS we draw the following conclusions. Firstly, the experiments clearly point to the need to distinguish more specifically between different bidding situations – first time versus repetitive buys from a fixed set of suppliers – and to allow for different degrees of knowledge on bidspreads. In addition, the ETQ-DSS could be improved by facilitating the phased approach that purchasers apply in practice. Differentiating between various levels of variable evaluation costs could do this. Still, given the apparent limitations that have to be overcome, the tentative version of the ETQ-DSS seems to provide very reasonable solutions in the cases tested.

General conclusions

As competitive bidding with tendering procedures is a widely used practice the ETQ model potentially has a lot of practical value. Especially with the development of the DSS the actual application of these calculations is encouraged as it provides a user-friendly interface and a clear overview of the results. However estimating the input parameters still seems not always that straightforward. Thus some improvement for de DSS can be made by providing additional help for this. Furthermore other bid distributions like the Student t-distributions need to be incorporated in the ETQ model as suggested by the empirical evidence on the bid distributions. Another way of looking at the bid distribution might be to consider each supplier having a separate bid distribution from which they 'pick' their bid. Then not only the economic tender quantity can be calculated, but also the economic tender set (ETS, see De Boer, Van Dijkhuizen, Telgen, 2000), meaning that not only the number but also which of the suppliers should be invited to tender. Another extension which was also indicated in one of the interviews was incorporating a two-step selection of suppliers using a pre-selection phase. This possible extension already has been investigated by Heijboer (Heijboer, 2001). Finally an important improvement would be to include multiple criteria (not only price) in the decision process as this would increase the number of situations to which the model is applicable, considerably.

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Figure 1: Trade off between tendering costs and the expected bids.

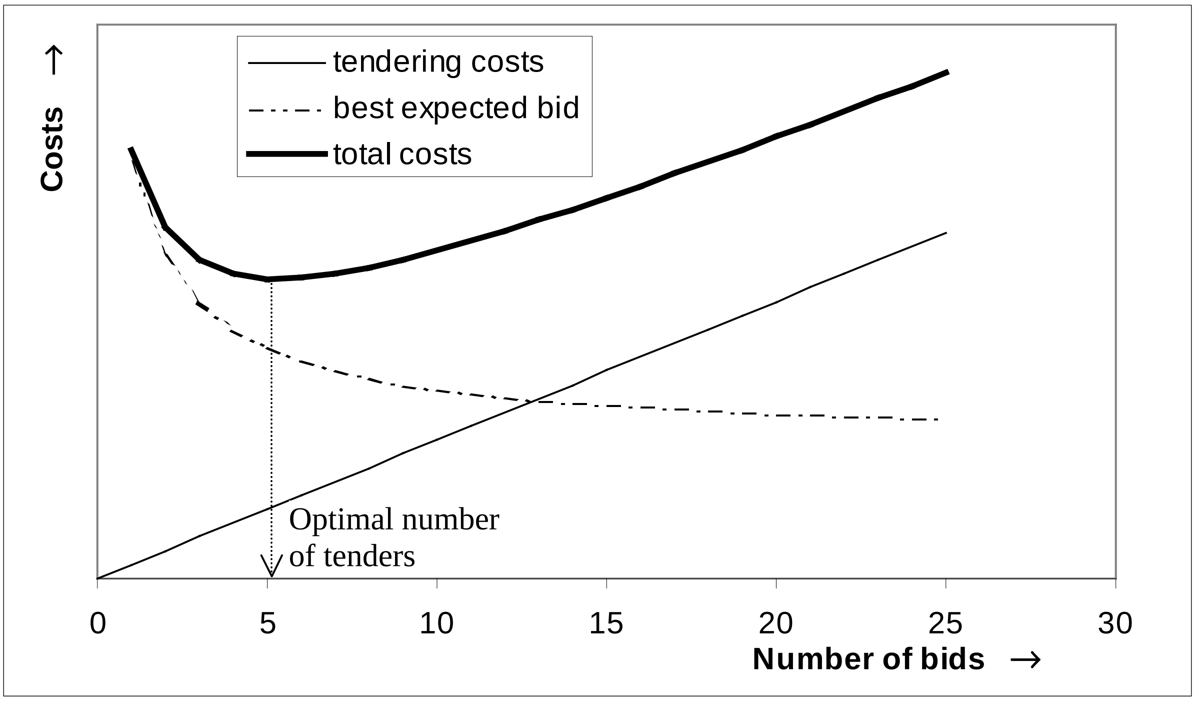

Figure 2: Determining the ETQ with a normal bid distribution (the bold numbers in the graph denote the ETQ in that area of the graph).

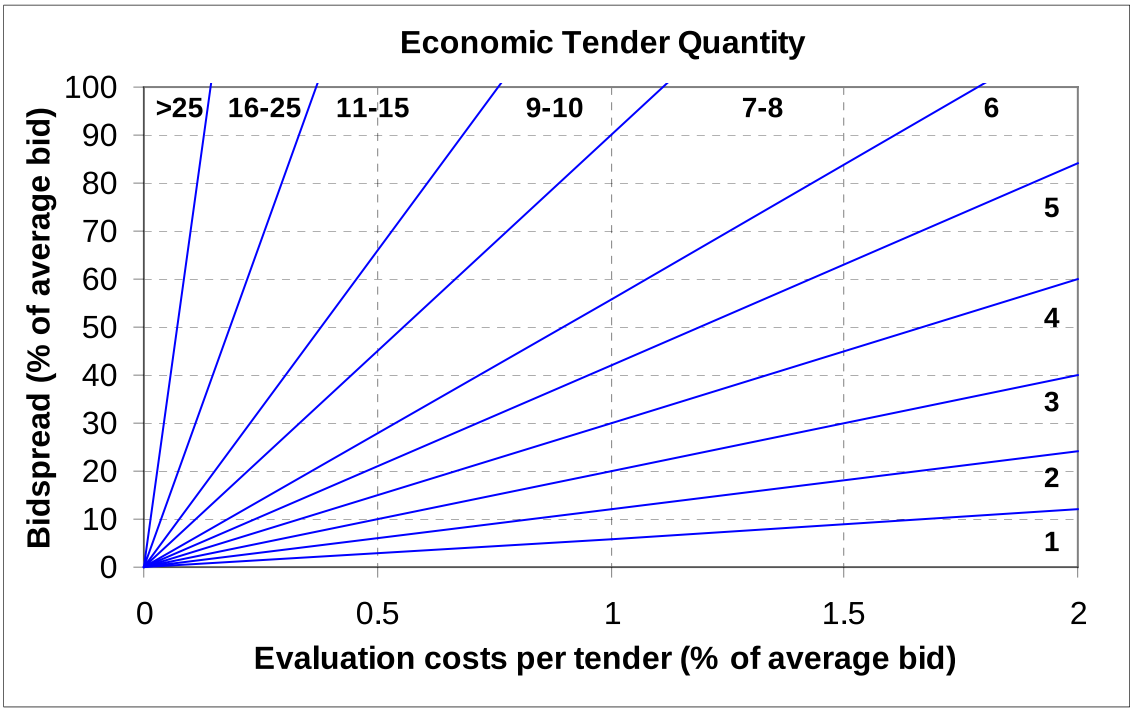

Figure 3: Q-Q plot for one case (bids for supplying PCs).

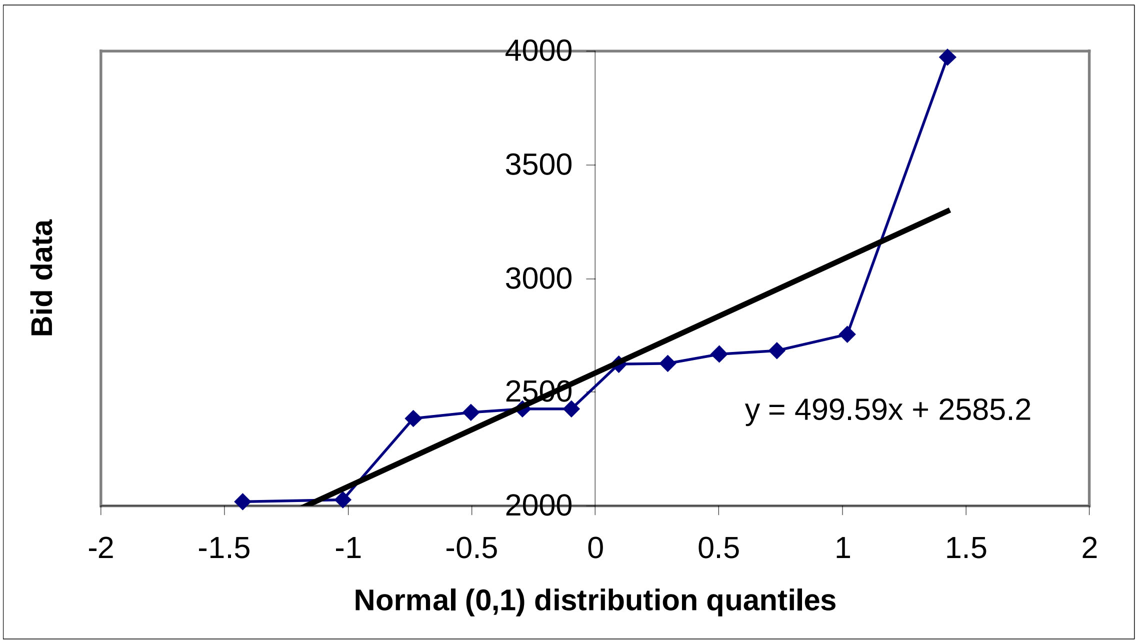

Figure 4: Symmetry plot of all the bid data.

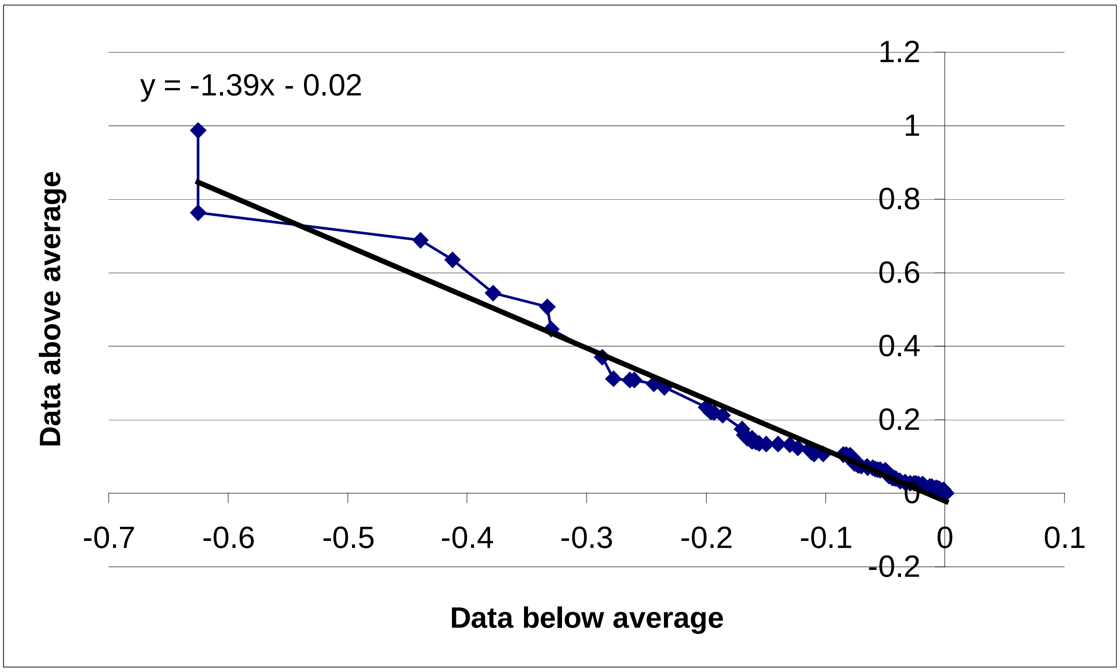

Figure 5: Q-Q plot of all the bid data.

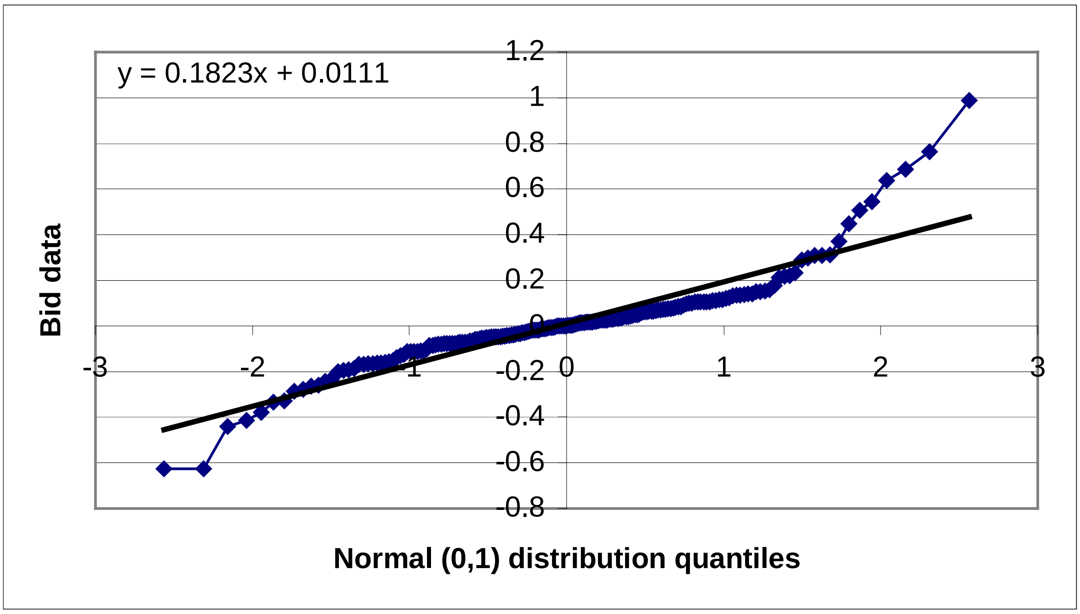

Figure 6: DSS for calculating the ETQ (a screenshot).