

Empirical Problems of Savings Calculation in Electronic Reverse Auction

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Abstract

The impact of reverse auction adoption has been a very important issue recently and is the subject of many studies. We are extending research results in the field of empirical studies by examining problems with reliability of methods for cost savings calculation of electronic reverse auction adoption in business processes. Reliability of savings proclamation in research studies or promotional materials is crucial for understanding real impact, benchmarking studies or comparison of several auction strategies from different auction environments. From our experience and empirical examinations, the problem for savings calculations is based on reliability and suitability of comparative or sometimes called expected price as the core factor for savings calculations when comparing with winning price. Our empirical study was based on real data from 1198 reverse auctions in Slovak commercial sector. On the base of our study, the most frequent strategy for electronic reverse auction adoption is multi-phase auction with first phase using sealed bid format. We have identified that reliability of using comparative prices as parameter for cost savings calculations vary according to different auction situations or settings and number of participants, auction volume and ratio of new participants are very sensitive for the reliability of savings calculations.

Keywords: Electronic reverse auction, Measurement, Savings, Reliability, Procurement

1 Introduction

Electronic reverse auctions (eRA) are one of the most important market mechanisms for negotiating more objective prices or utility of product and services in industrial sectors. In an auction, a good can be sold at a price determined by interactions of market subjects, which can partially substitute for perfect competition. Current competition and market conditions put pressure on improving efficiency of procurement processes and increasing competitiveness of industrial organizations. There has been an increasing number of eRA usage within industrial procurement processes and available software solutions on the market. eRA software providers are claiming significant benefits, esp. in savings by using eRA for purchasing different categories of products and services in commercial and public sector.

SW solutions are often designed with basic analytical tools to report auction history, key performance indicators and general results. However, several practical experiences show that there have been a number of constraints or unclear methods for standard calculation of real or objective savings achieved from realizing an auction. The reliability or standardization of correct calculation methods are critical to compare or understand real impact of eRA for concrete process, product or organization. At the most important event for eRA in Central Europe (eBF - eBusiness Forum held in Ostrava), this problem was identified by most of procurers and procurement managers as one of the most crucial problems in the field of eRA adoption and effective usage. Objective calculations would help procurement directors and managers not only to understand real impact but also provide them with strong arguments for promoting the value of procurement departments for a whole organization. Understanding the problems in savings calculations in real environment will help eRA SW designers, developers and market makers to provide suitable data model and algorithms used within analytical tools for correct savings calculations for efficient eRA management.

This paper examines practical problems of savings calculation based on data from real procurement processes conducted in SW solution ProEbiz as the most significant eRA SW solution in central Europe. The main focus of the study is the relation between a number of eRA-related features and the comparative price and the initial price, as these from the basis for savings calculation. We focus on problem identification, examination of its significance and possible solutions for more efficient and trusted eRA impact calculations.

2 Literature Survey

Over the last two decades, electronic reverse auctions have been used practically in almost every sector of the economy including aerospace, automotive, and industrial chemicals [59]. Reverse auctions are becoming more popular among buying organizations even though their use sometimes causes some controversy and ethical questions.

According to [7], eRA is an online and real-time ongoing dynamic auction between the purchase organization and a group of pre-qualified suppliers with some degree of visibility regarding the actions of their competitors who compete with each other in order to compete and obtain a contract for goods or services. The completion is based on several criteria such as design, quantity, required quality, delivery conditions and other related terms and conditions. Jap added to the eRA definition the positive aspect of lower restriction of geographical location and relatively low cost [32]. Together with [5], [38], the definition of the reverse character is based on the factor pushing the prices down in competitive and dynamic environment in which a number of suppliers compete against each other in real-time to win the business.

The greatest benefits and advantages of eRA adoption according to many authors [33], [37], [39], [53] can include: significant financial savings, the whole documentation of purchase, savings in transaction costs, total cost of ownership reduction, improving the quality and supply guarantees and the implementation of effective and routine procedures for procurement, access to new markets, break down geographical barriers, information transparency, generally higher competitiveness and general efficiency in the buying process [7], [10], [26], [38], [54], [55]. However, as resulted from [14], transparency in eRA is a much more complex phenomena and anonymity in e-auction can put pressure on e-auction participants to make more irrational decisions submitting lower prices.

The electronic reverse auction is usually initiated by the purchaser by sending a Request for quotation (RFQ). Bids of potential suppliers are then submitted on-line in real time. Invited suppliers compete with each other and each of their bids must be lower than it was previously (therefore term *reverse*). Auction usually begins on historic or reserve price, suppliers usually see the lowest bid at the time and also what price they will have to bid to get at the forefront of competition [47].

Most studies related to eRA consider the economic savings as the most crucial success factor [39]. Generally, the financial savings are defined as a reduction of the purchase price through competitive bids obtained through electronic auction [35]. The term savings is perceived as price benchmark for the purchased product/service negotiated through eRA to the amount of the costs we would incur if we had purchased in non-auction or electronic

environment. The definition of savings in the electronic auction is in itself a reason for its problematic measurement [61].

According to the study of [9], the perception of the electronic reverse auction impact by purchasers and suppliers is determined by cultural and regional factors. According to [51], the success factors of eRAs are the number of competing suppliers, the complexity of purchasing and specification of the purchased product. In their study also they pointed out that the factors, influencing the decision to use or not to use eRA, should not be based only on the number of suppliers. [1] in their case study proved that in the case of certain organizational conditions it is possible to achieve savings in line with building good supplier relationships. [25] in their study claim, that the price reduction and higher transparency is the most important factor for eRA adoption, although in specific situations, where a lack of confidence in the fairness of tender procedures emerged, the transparency can be a stronger driver than price.

Regarding differentiation of eRA usage and settings, several studies reveal the description of different types or algorithms of auctions. According to [61], there is still much confusion over what the difference is between auction types. There are many variations or formats based on a number of factors. Most often eRA types or formats significant for the impact on participants' behavior presented in different studies are based on price selection algorithms (first price, Vickery), direction of price changes (Forward, Holland, Reverse), transparency or dynamic character (sealed bid, dynamic auction, multi-phases auction), character of price submission (multi-round vs real time auctions) etc.

The real practice is characterized by a deployment of several auction process types. Multi-round auction is characterized by one bid per round submitted by each bidder. All bidders are informed of their competitor's bids only after the round has ended and the next round begins [34].

[43] analysed the latest academic developments in multiattribute online reverse auctions (MAORAs). They supported the idea of multiattribute auctions which can overcome that price only auctions and supported results also by [23]. Although, in this approach the attributes of an item as price, quality, warranty, or delivery time are used for the winner determination, the comparability between different auctions can be more difficult. In the case of this paper, we accept the common practice in multiattribute auctions in central Europe, where values for non-price attributes are mostly pre-defined as minimum requirements and core assessment criteria is focused on price.

Real time auction is characterized by publishing submitted bids by each bidder in real time bringing higher transparency to all bidders [21]. Multi-phase auction is the auction with more phases, where each phase can be based on different types of negotiation methods and lower number of participants against previous phases, e.g. English to sealed bid, sealed-bid to English and other combination of auction types or algorithms.

Generally, there exist a number of studies examining electronic auctions, its characteristics and impacts. Although, only a few of them are based on auction data. As stated above, several studies claim financial savings from 5% to approx. 40%. Most studies (e.g. [60]) are based on experimental research or simulations (games theory or mathematical modelling) where no practical restrictions existing in real practice were considered. [24], [31], [49] used mathematical simulations or modeling. Other studies used to apply experimental approaches by simulating auctions, e.g. [2], [4], [8], [12], [15], [22], [27], [30], [44], some experiments were conducted with students [11] or people from real business world ([63]) as participants. These experimental studies are generally based on calculation methods using a difference between modeled price or utility against winning price logically without considering accuracy of savings calculations. Empirical studies are based on questionnaires surveys or interviews with procurement managers or suppliers, e.g. [3], [29], [37], [48], [50]. [56] in their questionnaire analysis used price savings referring to the percentage change in contract price compared to the historical price. These studies together with deep interviews about small sample of auctions [1], [10] are based on the perception of target group and not on the data based validation. Research studies based on e-auction data from real procurement environment are unique and were realized on smaller sample of auction transactions, e.g. [6], [13], [15], [40], [58]. [41] analysed 770 e-auctions from different sectors obtained from one procurement SW provider which was till our research probably the most comprehensive Business to Business (B2B) auction data analysis in scientific studies. Savings calculated and analysed within these study were based on reserve price and buyer surplus calculation as the price of the lowest winning bid as a percentage of the historical price (BIDVHIST) but without taking into account the accuracy of historical price (price changes in time) or reserve price accuracy.

We were able to find only two scientific studies dealing with the importance of an accuracy of target price set up by procurement departments, which is crucial for savings calculation validity. All other studies relied on the procurement managers' skills to estimate the most suitable price. We have found one study [62] with the aim to validate reasonability of reverse auction usage in Army acquisition, underpinning the precise measurement of cost savings as a crucial factor for a process like reverse auctioning as it is always hard to do. This study was realized for the purpose of answering common reverse auction-related criticism question the legitimacy of savings calculations vis-à-vis the target price. The analysis was based on the target price definition by FedBid, where it is *usually based on a published catalog price or valid market research quote* but the accuracy was achieved by special screening process of auction data which should reduce the number of transactions with uncertain target price validity [46] in their memorandum from 2015 forced to review methodologies for calculating savings based on reverse auction usage to achieve. The second study was focused on the effect of cost estimation accuracy of bidding firms and their ability to

submit lower bids amounts and their likelihood of winning in a bidding environment [20]. The approach was based on the median of all companies' bids for a particular project as a benchmark to measure the accuracy of cost estimates, as the median was considered as a consensus of project value. Authors argued that companies with higher accuracy of cost estimation procedures, for whatever reason, will submit lower bids. Similar approach, although from the procurement side and focused on target price deviations from median, is used in our research.

3 Problem Identification

eRA solution providers but also other studies are often claiming significant savings achieved by using electronic reverse auction in real procurement processes. The impact vary but the most often average savings in percentage promoted in studies and promo materials are between 5-40% [14], [28], [37], [42], [51], [52], [53], [57], [60], [61].

Not all studies are so optimistic. Overestimated savings or unclear or not reliable results were claimed by ([7], [14], [16], [17], [18], [19], [36], [44]).

As discussed already above, methods for savings calculations mentioned studies often doesn't reveal the clear method or they are based on method based on calculation by taking the difference between the Buyer's target or expected price and the awarded price. The principle is based on including an expected payment amount as the *target price*, based on the buyer's own market research. See more at FedBid page (Site 1). In the case of multi-attribute auctions, which are generally focused on more attributes then the price, according to our experiences and data from central Europe procurement environment, the most frequent approach is a pre-definition of minimum values of non-price attributes (pre-qualification of bids) and then to focus more on price or in real multi-attribute auctions, the weights on the price as one of attributes assessed in the auction were mostly above 90%, again setting price as the dominant factor.

When promoting an impact of reverse auction adoption of different types and sectors, the validation of impact or savings calculations is crucial to be able to trust not only scientific papers but also commercial promotion campaigns. In the public sector, like in the case of the US Army, the development of trusted methodology for savings and impact calculation is necessary to increase trust in and validation of public spending reasonability.

That's the reason, our paper is focused on the revealing practical problem of savings calculation based on real auction data from ProeBiz, the B2B electronic reverse auction solution by NAR Marketing, s.r.o., the most significant provider in Central Europe. We are analyzing the practical approaches to savings calculations and their limitations in real auction environment through analyzing deviations in the accuracy of target price estimation against initial price defined by best price identified within first non-auction round (similar to the best catalogue price from the market survey).

3.1 Empirical eRA Process Description

Standard process of dynamic procurement using eRA SW solution will be described according to our experiences from central European enterprises and public organizations attending EBF Forum held in Ostrava as the most significant and biggest eProcurement event in central Europe. The process is generalized according to the most common eRA process settings by procurement specialists and simplified for understanding only related savings calculation issues.

The auction system is based on multi-phases, real time and optionally multi-item or multi-criterial characteristics. For multi-phases settings, the procurer is able to select different types of auction phases, most often combination of sealed bid and first price reverse auction. We are using terminology generally used in several auction studies where multi-phased auction is described as auction with several stages of different negotiation types and multi-round auction is described as non-real time auction providing several rounds where bidders have only one chance to submit his offer. Although, from our experiences of real practice, the term round is generally used for phase.

As a first step a procurer has the choice to identify comparative or sometimes called target price as a result from his market survey or experiences from historical contracts. This step is not obligatory, but it is used very often to analyse auction results. Then, he sends an invitation to participate in the auction through the e-auction system to potential suppliers (auction participants). This invitation includes description of procurement request, e.g. criteria for eligibility, auction settings, the winner selection procedure etc. To obtain a Pass Code and log into the electronic auction the supplier is obliged to submit filled application form. The application provides possibility to enter to the eAuction system in the future with authentication data and the option to compete in the auction rounds. eAuction can be focused on price negotiation or multi-attribute negotiations.

The electronic reverse auction usually begins with the input phase, in which the first bid is submitted. Input phase is most often a sealed bid which serves as first phase to market survey and identification of reserve price for next auction phase. Generally, bidders are aware of second auction phase. After that, control (for control of submitted data to reduce errors) or directly auction phase usually begins. Phases of eRA can be set up only by the procurer who determines also its length. The minimum length of the input phase is usually 3-4 days (it is important that

potential suppliers have sufficient time to prepare all the documentation carefully). E-auction system provides information about the currently ongoing phases and time till the end of the phase. In some cases, the participant doesn't need necessarily to enter his bid in the input round (if not required), just to compete actively in the next dynamic auction phase. Regarding dynamic auction phase, the practice shows that it should not take longer than 25 minutes. Generally, e-auction systems offer the possibility of prolongation of real time auction phase when prices are changing in last few minutes. The optimum condition recommended by procurement specialists is two minutes for each prolongation. Several prolongations are possible. Basic setup of dynamic auction involves determining the exact date and time of the start of the auction, the type of auction (ermm, NIPPON, HOLLAND, etc.), ranking and selection criteria, minimum and maximum price reduction, members of external auction monitoring commissions, the optional conditions (maturity of invoices in days, the warranty period in months, delivery date in days or references of participant), visibility of several negotiation parameters (transparent publishing of number of participants, their prices, best price, ranking of participants etc.). Procurement director and manager have the possibility to monitor auction results and basic analysis. Although in few cases, single auction phase was realized.

3.2 Characteristics of Parameters Used for Savings Calculations

When we are considering the savings calculations for auction impact reporting based on basic eRA process settings, the most sensitive issue is the identification of the price which is needed to be compared with winning or final price negotiated for the final contract. From our experiences, procurement managers are using two basic types of comparative prices:

- Comparative price (sometimes also called expected or target price): defined or estimated by the procurer as result from his market survey or price from last contract. This price is subjective and very sensitive on the procurer's ability to analyze suitable data sources. In the case of using the price from last contract, the price can be volatile within this last time period and can be risky for estimation the expected price. On the other hand, the estimation of price from market survey is determined by the number of market subjects or market transparency.
- Initial price: defined generally as best price from input phase, which can be considered as reserve price. The problem with this option is the different perspective mainly in the case of comparison between dynamic auction and sealed bid types.

According to general processes identified from our observation in real B2B practice, we can identify the following basic approach for savings calculations methods.

3.2.1 Single Auction Phase

In the case of single auction phase, where no input phase exists and participants submit their prices in real time dynamic auction within specified time, we have identified several options of comparative price identification used for savings calculations:

- Option 1. Initial price of single auction round from time perspective. For savings calculation, the first price submitted in single auction phase is used. The risks with this method is higher probability that supplier will test the price, generally higher than his catalogue price. From a practical point of view, sometimes typing errors happened, e.g. mistakes in decimal point or numbers of 0 in the number.
- Option 2. Highest price from first prices submitted by each participant. From several bids within whole time period of dynamic auction phase, the highest price is selected to show how auction can reduce the real market price. This method is not often used, although in some cases we have observed this approach, esp. for promotion purposes. Typing errors can harm calculations from real data.
- Option 3. Lowest price from first prices submitted by each participant. From all prices firstly submitted by bidders, the lowest value will be submitted. This approach can be used as an alternative to input phase. Although, it has logical sense only in the case when prices will be submitted sequentially or in short time to avoid price determination of later price submission when already submitted and especially already reduced prices as result of competition between other bidders can determine till the time non-active bidder submit lower price as it would be in input phase. Typing errors can harm calculations from real data.
- Option 4. Comparative price estimated by procurer. Comparative price as expected price subjectively estimated by procurer can be then compared to the winning price.

3.2.2 Multi-phase auction

In the case of multi-phase auction, the procurer will set up several phases, usually two. First phase for first input prices and second phase for dynamic competition in real time auction. Then, the comparative price for savings calculation can be identified as follows:

- Option 5.1. Best price from first input phase (sealed bid phase) with information about second phase, second phase = dynamic auction phase: In first phase, bidders submit their prices but don't see submitted prices of other competitors. Bidders have the information that after input phase, the dynamic auction phase continues. This option can determine prices submitted in first input phase because of revealing information about possibility to reduce bidder's price in later phase.
- Option 5.2. Best price from first input phase (sealed bid phase) without information about second phase, second phase = dynamic auction phase: In first phase, bidders submit their prices but don't see submitted prices of other competitors. Bidders don't have the information if the dynamic auction phase will be opened after the sealed bid phase. This option can determine prices submitted in first input phase because of no information about the possibility to change the price later. The best price from input phase is close to real standard market survey.
- Option 6.1. Best price from first input phase (transparent one auction round) with information about second phase, second phase = dynamic auction phase: In first phase, bidders submit their prices in a transparent environment and are able to see submitted prices of other competitors. Bidders have the information that after input phase, the dynamic auction phase continues. This option can determine prices submitted in first input phase in two ways: bidders submitting their prices later can reduce prices because of visible prices already submitted; price determination because of revealing information about possibility to reduce bidder's price in later phase. This approach can be compared to single dynamic auction, although the problem of option 2 and 3 from single auction phase will be avoided.
- Option 6.2. Best price from first input phase (transparent one auction round) without information about second phase, second phase = dynamic auction phase: In first phase, bidders submit their prices in transparent environment and are able to see submitted prices of other competitors. Bidders don't have the information if the dynamic auction phase will be opened after the sealed bid phase. This option can determine prices submitted in first input phase because of no information about the possibility to change the price later. Although, in the first phase, bidders submitting their prices later can be determined by visible prices already submitted before their submissions.
- Option 7. Comparative price estimated by procurer: Comparative price as expected price subjectively estimated by procurer can be then compared to the winning price.

Summarization of factors determining practical savings calculations:

1. The auction process can include sealed bid as first/input phase.
2. Best price from sealed bid phase can be considered as basic market price which should be benchmarked to the comparative price, it means, the precision of comparative price estimation can be defined by the difference between the market price and sealed bid.
3. Sealed bid price is determined by the number of auction participants or new (till the beginning of the auction) unknown suppliers which has the certain probability of better price than known suppliers from past contracts.
4. Sealed bid has no time characteristics as real time dynamic auction. It means no initial price can be considered without time as parameter for savings calculations.
5. Sealed bid as a first round of auction is suitable for initial/reserve price estimation.
6. Although, sealed bid round within auction process doesn't have necessarily the character of single sealed bid because of possible participants' awareness of continuation in the later dynamic real time auction phase.
7. In the case, the first round of auction is not exactly sealed bid but in the form of open tender (with partial time characteristics, where participants have possibility to input the prices within time interval), from the aspect of initial price analyses, it has no sense to consider first price within the time interval as initial price for savings calculations because of no transparency for participants.
8. Within single dynamic auction phase, initial price can be used for savings calculation with some limitation of testing character of first price submitted.
9. Comparative (expected, target) prices can be estimated with different levels of precision.

Considered limitations of parameters validation for savings calculations:

1. Factors determining decision making of price inputs as parameters for savings calculations
 - a. Awareness of participants if auction continues after sealed bid input phase.
 - b. Transparency of input prices between bidders within first input phase.
2. Factors determining probability of market price achieved within first/initial phase
 - a. Number of until now unknown suppliers.
 - b. The possibility of optional (not obligatory) input of supplier's price within first/input phase.
3. Factors when no first input phase exists (single auction phase):
 - a. Errors of input or submitted prices
 - b. Testing character of first price can be higher than standard catalogue price
 - c. Method for calculation between first-last vs highest-last price

According to factors and limitations mentioned above, objective value of savings is suffering from characteristics of several price types used for savings calculations. That's why, the examination of different types of comparative price based on real data is necessary to better understand the validation and characteristic of savings calculations.

Better understanding the objective value of these calculations can improve trust, reliability and comparability of several results in the field of e-procurement analysis and impact of eRA adoption together with improving their management and efficiency. On the other hand, validation of other types of prices as comparative (expected, target) price can impact on cost related to market survey. Together, eRA SW development can be effectively determined, esp. when providing standardized data model and analytical services for comparison purposes of shared data from procurement processes or related collective awareness platforms.

4 Comparative vs Initial Price Examination

To examine differences between different price types used for savings calculations we have used data from real eRA processes. We have obtained the data from ProEbiz SW solution, the most significant and biggest eRA SW solution in central Europe. The auctions were realized within various sectors (building and construction, energy, transport, office supplies etc.), although the precise sector categorization of each auction was not possible to identify due to nonexistent product classification standardization.

In this chapter, we will examine behavioral characteristics of two types of prices used in our cases: Comparative and Initial Prices, where Initial Price is considered as best price of first input phase based on sealed bid type. We will analyze and identify procurement situations where specific type of price is better to use for savings calculations. The analysis will be based on difference calculations between Comparative and Initial Price and analyzing factors determining the lowest and highest difference which can describe precision of Comparative Price estimation, which is usually used in different cases, e.g. FedBid.

4.1 Methodology and Sample Description

The study sample contained data regarding 1198 auctions with 13138 items purchased between 2010 and 2014, realized by 21 different procurers where the Initial and Comparative Price were of interest (generally option 5.1 as described above with very small number of single auction insignificant for this research). To enable us to study the differences occurring between these prices, the following formula was used to quantify this difference and to correct for different nominal volumes of individual auctions:

$$diff=abs(1-Comparative Price / Initial Price) \quad (1)$$

It returns $diff=0$ if the prices are equal and an increasing positive number with the gap between these prices widening (this is sufficient as this study does not investigate which of these two prices is higher, only if there is a difference). For further analysis, the standard Mann-Whitney U test and decision trees formed based on the Chaid algorithm in SPSS were used. The resulting distribution of the studied difference characteristic along with the Comparative and Initial Price comparison is provided in Figure 1.

4.2 Analysis of Parameters Determining Savings Calculations

When analyzing determinants possibly affecting the difference between the Comparative and Initial Price, all available variables were considered. Since the *diff* variable was tested not to be from a Normal distribution and its observations were not paired, the standard Mann–Whitney U test was performed on samples created by dividing the *diff* variable into two groups using the median for each studied variable. Variables that were considered (limited by data availability) to have an impact on the difference between the Comparative Price and the Initial Price along with results of the Mann-Whitney U test performed are provided in Table 1.

In the case of the variable No. participants, the number of participants of the auction was taken into account, with statistically significant differences detected between auctions with number of participants below the median number of participants of all auctions and auctions with above median number of participants. The sample with above median number of participants was found to present higher differences between the Comparative and Initial Price.

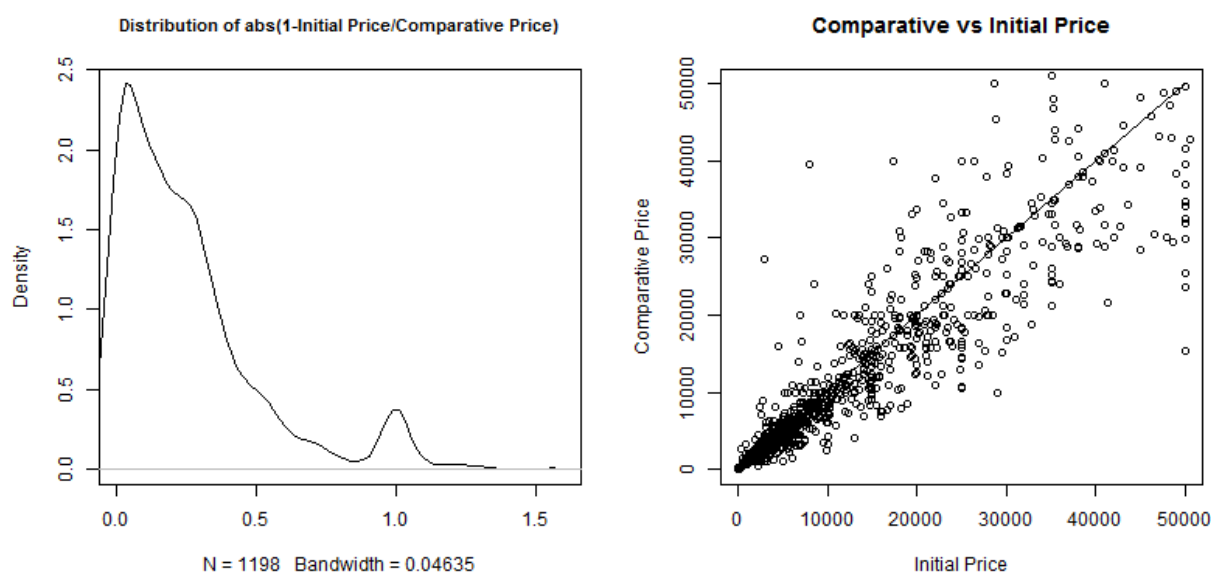


Figure 1: Difference between Comparative and Initial Price

Table 1: Impact of variables on the difference between Comparative and Initial Price

No. participants	
W = 138202.5	p-value = 6.055e-12
No. items	
W = 83703.5	p-value = 0.956156
Best offer before auction	
W = 135479.5	p-value = 0.088868
Winning offer	
W = 140254.5	p-value = 0.001055
No. Invitations	
W = 182248	p-value = 0.634308
New applications	
W = 166031	p-value = 0.025552
Placed an offer	
W = 168850	p-value = 0.364609
No. extensions	
W = 143191.5	p-value = 0.059392
No. changes	
W = 143915	p-value = 0.718666

The second variable found to have a statistically significant impact on the difference between the Comparative and Initial Price was the variable Winning offer, representing the nominal value of the auction expressed as the winning offer accepted. Auctions with below median Winning offer presented higher differences between the Comparative and Initial Price. This can be due to the fact that when dealing with numerically low amounts, rounding and estimation errors along with small numerical changes cause high differences in relative terms, although remaining relatively insignificant as a whole. The last variable to be found to have a statistically significant impact on the difference between the Comparative and Initial Price was the variable New applications, representing the number of new registrations of participants who did not previously participate in the auction system. Auctions that managed to attract new participants presented higher differences between the Comparative and Initial Price. Variables that presented no statistically significant impact on the *diff* variable included No. items (number of items in the given auction), Best offer before auction, No. invitations (number of invitations sent out to possible participants), Placed an offer (number of participants that placed at least one offer during the auction), No. extensions (number of times the auction has been extended) and No. changes (number of times the winning offer changed during the auction). The distribution of the *diff* variable and comparison of Comparative and Initial Price divided by the median of the studied variable is presented in Figure 2. Simple linear trend has been added to the graphs (dashed line) to represent which price is dominant in the case a difference is present.

To analyze the causal factors affecting the difference between the Comparative and Initial Price in more detail, the method of decision trees has been used. The decision tree based on Chaid algorithm generated in SPSS Clementine and best describing the studied data is presented in Figure 3.

The comparison of Comparative and Initial Prices for each node of the decision tree is presented in Figure 4, along with simple linear trends added to visualize the direction of the difference between the Comparative and Initial Price.

As can be seen in both Figures 3 and 4 auctions with number of participants higher than 6 display a higher difference between the Comparative and Initial Price, with Initial Price being higher on average. This fact suggests that the expenses for estimating the Comparative Price in auctions with a low number of participants are not effective and organizations can rely on Initial Price, as there are not significant differences among the two and selecting either one has no noticeable impact on savings calculation reliability. In the case of auctions with high number of participants, the reason for the Comparative Price being lower than Initial Price on average can't be explained sufficiently without the knowledge of what the process behind the estimation of the Comparative Price was. This possibly brings up the need for implementing the functionality of indicating this process into auction systems. Both Comparative and Initial Price have their own risks concerning savings calculation reliability. In the case of Comparative Price, it is the variance of prices depending on the method of estimation used. In the case of the Initial Price it can be the risk of auction participants artificially inflating the Initial Price when depending on the following auction process (see *Option 5.1* or *6.1* in previous text). In the case of auctions with 3 or less participants, low value auctions with Initial Price of 4000 or less EUR present an increased difference between Comparative and Initial Price, with the Comparative Price being higher on average, suggesting the use of Initial Price for savings calculations to be more reliable (closer to market price). The reason for higher Comparative Prices can be the fact, that costs of prolonging the negotiation process in comparison to setting a low Initial Price by the participant are not efficient due to low total value of the auction. In the other case of higher Initial Price (with low number of participants) it seems to be inefficient to estimate the Comparative Price, as its use for savings calculations in comparison to the Initial Price is negligible. In the case of auctions with a high number of participants and ratio of new participant applications over 63.6%, increased differences between Comparative and Initial Price were present. The difference shifted towards Comparative Price being higher than Initial Price. In comparison to the effect of high number of participants in general, the situation is reversed here, meaning that a high number of participants does not ensure a lower Initial Price unless these participants are new. In this case however, using the lower Initial Price in savings calculations can cause an artificial reduction in savings and auction efficiency (as the new participants often present lower Initial offers than participants known from previous auctions). For this reason, the new participant ratio is becoming a very sensitive factor when comparing reverse auction impact in different environments. The last subset selected was the specific case of an auction with 3 or less participants, with Initial Price of more than 4000 EUR and a single participant submitting an offer. This case has many specifics with often Comparative Price being derived from historical prices of the same participant with little or no price volatility. From the savings calculation point of view, differentiating between Comparative and Initial Price is insignificant.

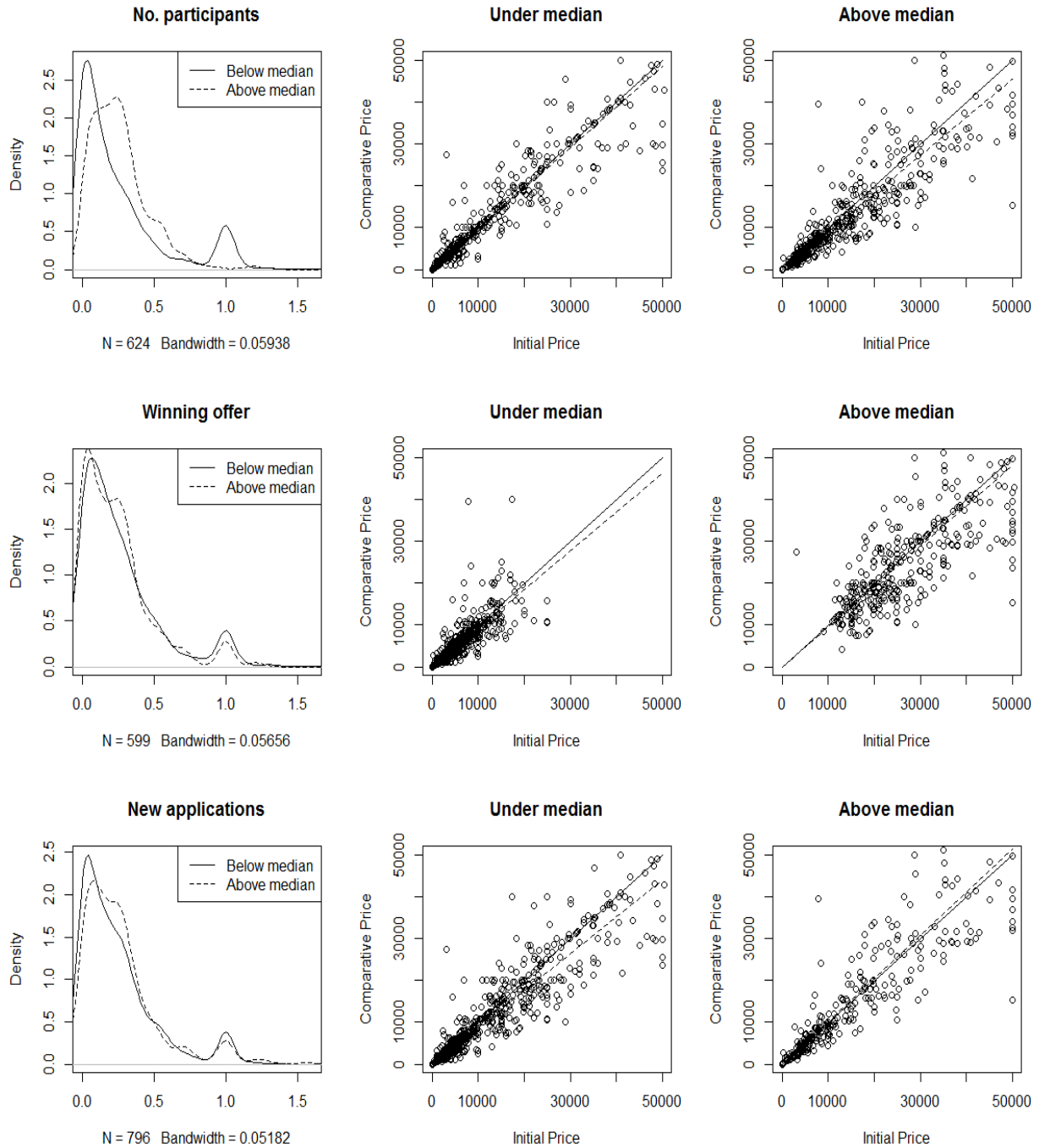


Figure 2: Comparison of comparative and initial price for studied variables

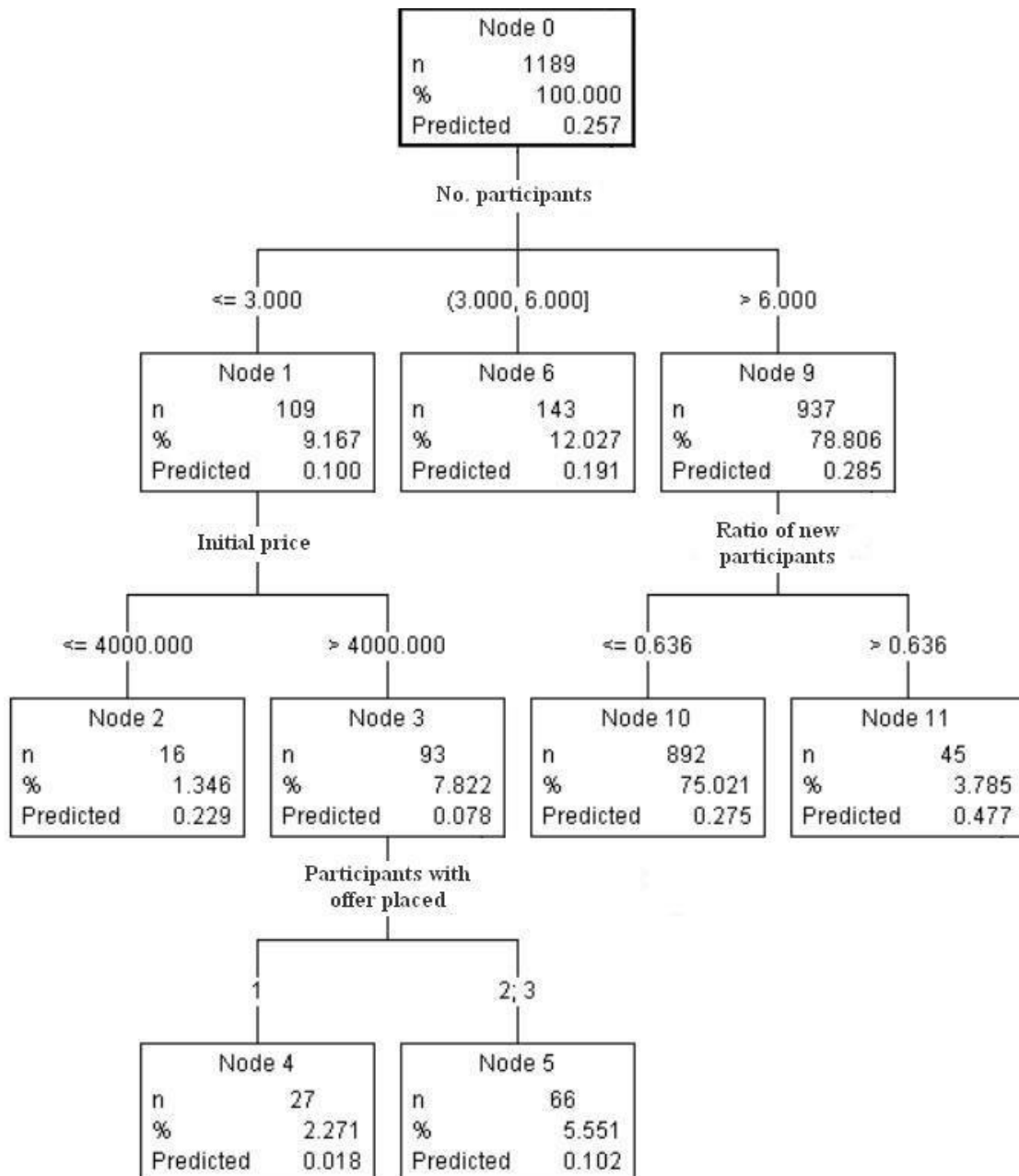


Figure 3: Decision tree with rules for *diff* classification

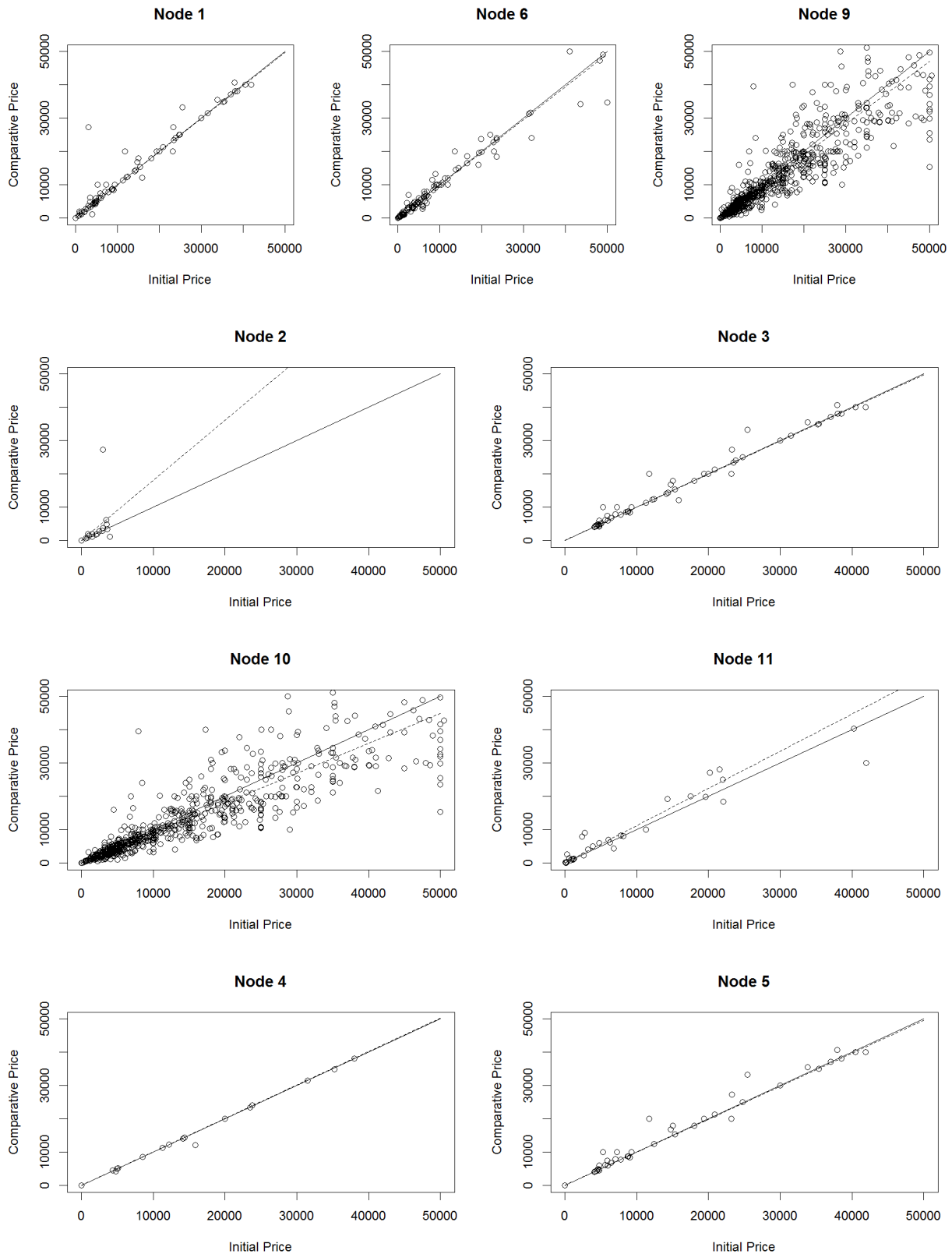


Figure 4: Comparison of the comparative and initial price for individual nodes of the decision tree

5 Conclusion

The impact of reverse auction adoption has become a very important issue in the past several years and is the subject of several studies. Although most of the studies are focused on experimental research, we are extending research results in the field of empirical studies with focus on examining problems of reliability of methods for cost savings calculation using eRA in business processes. Reliability of savings proclamation in research studies or promotional materials of different subjects including governments is crucial for understanding the real impact, benchmarking studies or comparison of several auction strategies from different auction environments. From our experiences and empirical examinations, the problem for savings calculations is based on reliability and suitability of comparative or sometimes called expected price as a core factor for savings calculations when comparing with winning prices. We focused on several problems in different situations.

Our empirical study was based on real data from more than 1000 reverse auction in Slovak commercial sector what seems to be the most comprehensive study based on B2B real auction data. Based on our study, the most frequent strategy for electronic reverse auction adoption is multi-phase auction with first phase using sealed bid format. We have identified that reliability of using Comparative Prices as a parameter for cost savings calculations according to formula 1 vary according to different auction situations or settings.

In general, we see problems in reliability of using Comparative (expected or target) Price in following situations:

- When significant differences in the number of participants across auctions in the sample exist, using Comparative Price in the case of higher number than 6 show uncertainty regarding reliability of Comparative Prices because of generally higher Initial Price, which can evoke not precise estimations of Comparative Prices and harming real cost savings calculations.
- In the case of auctions with 3 or less participants and low value with Initial Price of 4000 EUR or less, reliability of using Comparative Price for calculations is very low as Initial Price is much more lower than Comparative Price and can be considered as real target price.
- A Very significant factor is also the ratio of new participants in the auction. High number of participants together with high ratio of new participant applications creates a high market transparency pressure leading to achieving a more realistic market price, which can harm reliability of using Comparative Price for savings calculations.

According to our results, when calculating savings from eRA adoption, precise calculations should take into account mentioned specifics of Comparative vs Initial Prices. We have identified several cases, when using the Comparative Price is not efficient and in calculations Initial Price should be taken into the consideration for respective sample of data.

In general, for improving reliability of any savings calculations, we recommend software system functionality to include the possibility to submit method for Comparative Price estimation. The importance for using Comparative Price is based also on efficiency of procurement cost, where also cost for market survey can be, in particular cases, significant.

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Websites List

Site 1: FedBid: Customer input is the key to savings calculations

<http://www.fedbid.com/blogs/customer-input-is-the-key-to-savings-calculations#sthash.oYFk9szH.dpuf>

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