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Factors influencing savings from electronic auctions

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Abstract

The ratio of public procurement undertaken through reverse electronic auctions is increasing rapidly. Czech and Slovak municipalities use this tool to save public funds through fostering direct competition between suppliers and to increase transparency. The main aim of this paper is to analyse the savings achieved through e-auctions and the factors influencing these. Five variables are tested to establish whether they influence the savings: number of participants (potential suppliers) in the e-auction, total value of the e-auction, size and country of origin of the municipality, and category of the procured product or service. Several methods are used to test independence. All of these factors except the country of origin influence the savings gained, which is in accordance with the findings of existing research.

Keywords

Electronic auctions, non-parametric tests, public procurement, savings.

JEL Classification: H57, M11

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1. Introduction

Electronic procurement has become a valid part of purchase processes not only in private companies, but also in public institutions. It is seen as an integrated solution for all procurement processes throughout an organization and it uses a sequence of tasks based on electronic systems for communications and processing throughout the procurement chain (Costa et al., 2013). E-procurement is somewhat specific when it comes to government organizations, which tend to be traditionally more rigid and bureaucratic (European Commission, 2010). The benefits of public e-procurement are seen as highly prospective by the European Union, as specified in the Manchester Declaration (2005). It stated that by 2010 all public organizations should carry out at least 50% of their procurement electronically and should have the ability to raise this ratio up to 100%. This goal was later postponed to 2020 as less than 5% of public procurement cases were conducted online in 2010 (European Commission, 2010).

One of the most important parts of computerization (together with e-marketplaces and e-catalogues) is the reverse electronic auction (e-auction) process, which helps organizations attain savings in the purchase process and also provides other benefits. E-auctions provide potential suppliers with the space to compare and compete in pricing, which usually leads to reductions in prices and objectification. According to Beall et al. (2003), an e-auction is *an online, real-time dynamic auction between a buying organization and a group of pre-qualified suppliers who compete against each other to win the business to supply goods or services that have clearly defined specifications for design, quantity, quality, delivery, and related terms and conditions.*

E-auctions originally spread in the mid-1990s, mainly in the procurement processes of private companies. Later, public organizations also began to adopt e-auctions. Some countries made e-auctions compulsory, either for all government purchases or at least for some commodities. According to Shalev and Asbjørnsen (2010), e-auctions are mandatory, for example, in Australia, Canada and France. The best example of the legal inclusion of e-procurement and e-auctions is Portugal, where all government procurement is done

electronically and most of the data are available to the public (Costa et al., 2013).

The situation is more complicated in the Czech Republic and Slovakia, as the laws on public procurement alter with the changes of political incumbents. In Slovakia, e-auctions are mandatory to a certain extent, whilst in the Czech Republic the Ministry of Local Development issues a list of commodities that are appropriate for e-auctions.

The goal of this paper is to determine the influence of certain factors on the success of an e-auction. The result of an e-auction is assessed on the basis of the financial savings obtained through the e-auction against the procurement case without the e-auction (in other words, we compare the best offer in the e-auction to an estimated price, which is usually based on the estimated price or best offer before the auction). The data used in the research were gathered from the e-auction software Proe.biz, which is operated by NAR Marketing, s.r.o. This system contains data on all e-auctions conducted by Czech and Slovak municipalities in the years 2011 and 2012.

2. Theoretical background of e-auctions

E-auctions have become the topic of many academic studies. Authors have focused on the benefits that e-auctions provide to the contracting side or the whole market (Manoochechri and Lindsay, 2008; Kaufmann and Carter, 2004). The advantages include, but are not limited to:

- financial savings (usually around 15% of the initial price for first-time purchases),
- increased market efficiency (open environment for buyers and sellers for comparison of true values of products and services),
- improved procurement process efficiency (time savings for both sides),
- access to a larger supplier base (fewer geographical limitations).

Soudry (2004), who examines e-auctions from the point of government contractors, adds to these benefits transparency in the management of public funds. He contends that electronic forms of procurement should be preferred over the traditional forms because of the

lower possibility of influencing the procurement process through unfair behaviour, such as corruption or logrolling. They also help to dismantle preferential purchasing patterns and open up the market for competitors from different regions or countries.

There are of course certain prerequisites for attaining these advantages. According to Tarazona Bermudez et al. (2014), the main conditions are:

- clear and comprehensive specifications of the product or service;
- a purchase large enough to provide an incentive to participate;
- appropriate supply market conditions and infrastructure.

Smeltzer and Carr (2003) further discuss the importance of the clear specification: they argue that meeting this criterion is especially hard for some services or conditions, which often cannot be stated precisely. It is therefore advisable for the purchasing company to delineate and write down clear specifications for and related expectations of the purchased product. The second condition is usually met through merging the purchases for the whole company (not just one branch, subsidiary or department), or over longer time intervals (usually contracts for one year of supplies). This is convenient not only for the suppliers, as they are more likely to participate in higher-volume e-auctions, but also for the buyer – the procuring company saves a significant amount of time and resources on these aggregated purchases. The third criterion focuses more on the external environment of the purchasing company: for some markets, the circumstances might not be right to attract high savings as the potential suppliers may already be selling most of their production capacity to existing customers and thus have little to no interest in acquiring new ones. The prices in the market should also be elastic, an aspect closely related to the two previous conditions. As for the infrastructure, the company needs to view e-auctions as a tool within the strategic sourcing process. Professionals who understand these instruments need to be signed or trained. Furthermore, if reverse e-auctions are seen as a threat to traditional preferential buyer-supplier relationships, employee sabotage could occur.

Janke and Kubačka (2013) address the problem of measuring e-auction success. Some of the benefits are very hard to compare or compute (such as the higher efficiency of the market or the reduction in unfair behaviour). Therefore, the authors conclude that the most comprehensive method is to measure the financial savings derived from an e-auction. There are several ways of calculating savings: savings based on the estimated price and savings based on the initial price. The estimated price is usually based on the

purchase price of the commodity before an e-auction, or on the expert estimation of the purchaser, or a combination of both. The initial price is the best price after an initial round in the e-auction, in which all qualified suppliers are asked to submit offers. The authors conclude that these two variables are highly correlated and therefore basically substitutable. The reason for focusing on the financial benefits of an e-auction is the availability of the data: researchers usually have at their disposal only quantitative data concerning e-auctions and other conditions, whereas the consequences of an e-auction remain hidden (e.g. if the e-auction successfully prevented corruption or other unfair behaviour).

Many authors focus on the dependence of the savings on other factors. Carter and Stevens (2006) performed an experiment to examine the results of fictive e-auctions under different conditions with students acting as participants (both on the buyer and supplier side). They found that e-auctions with more competing suppliers tend to have higher financial savings and the settings of the auction (e.g. the visibility of all offers or just the best offer) also influence the output of the e-auction. E-auction settings could not be tested in this paper as the data set provided lacks information on the specific e-auction setting.

Prídavok and Delina (2013) examined real data from e-auctions in Slovakia, focusing on variables influencing the savings in an e-auction. They support the claim that savings depend mostly on the number of suppliers. Another variable potentially influencing the result of an e-auction is the total value of the e-auction (measured in units of currency). However, the authors dispute the merit of this influence, as the correlation coefficient is very small for this variable. They also found that the general settings of the e-auction (or its complexity, to be more specific) have a negative effect on the result, which means that more complicated settings lead to lower savings. The authors assume that the main reason for this rather surprising finding is the lack of expertise and experience of the employees who set the configurations of the e-auction process.

The closest research to that of this paper is the work of Pavel and Sičáková-Beblavá (2013), who focus on e-auctions in the public sector. They further support the correlation between savings and the number of suppliers (expressed as the number of offers). They also examine whether using e-auctions leads to an increase in the number of bids submitted (basically the aforementioned 'access to a larger supplier base' benefit of e-auctions), concluding that this relation does exist.

3. Research methodology

In this section, the data used in the research and methods of analysis are discussed. A quantitative research approach was employed in the study.

3.1 Data

The data for this research were acquired from the company NAR marketing s.r.o. The data set contains all e-auction cases for Czech and Slovak municipalities in the years 2011 and 2012 using the e-auction system PROe.biz. A total of 2,756 e-auctions were included in the research, but it was necessary to clean the sample, eliminating e-auctions with missing data (i.e. the estimated price or specification of the purchased item). The final sample size was 1,249 e-auction cases. The list of variables used in the analysis is shown in Table 1.

Table 1 Analysed variables

Variable	Type of variable
Savings based on estimated price	quantitative
Total value of the e-auction	quantitative
Number of participants	quantitative
Size of the municipality	ordinal
Item category	nominal
Country	nominal

The variable *savings based on estimated price* is used as a measure of the success of the e-auction (see section 2 and the findings of Janke and Kubačka, 2013). The savings can be computed as

$$S_R = \frac{P_E - P_{BO}}{P_E}, \quad (1)$$

where S_R is relative savings, P_E is the estimated price and P_{BO} is the best offer received in the e-auction. As previously mentioned, the estimated price can be taken from previous procurement cases of the same item, or it can be assessed by an experienced expert in the procurement department. The estimation usually comprises a combination of a short market survey and the subjective judgement of the expert. In some rare cases, *savings based on estimated price* can be negative as the estimated price might be approximated for a market situation that no longer pertains and it is therefore not possible to buy the item for the estimated price, or the purchase expert may provide an inaccurate estimation.

The *number of participants* denotes the number of suppliers invited to the e-auction, registered for it and made at least one offer. These criteria were set because suppliers sometimes register for an e-auction not to win the contract but to see the offers of other competing suppliers so they can evaluate their competitive strength. The average number of suppliers, as

can be seen in Figure 1, was around 4.5, with a mode of 3 suppliers.

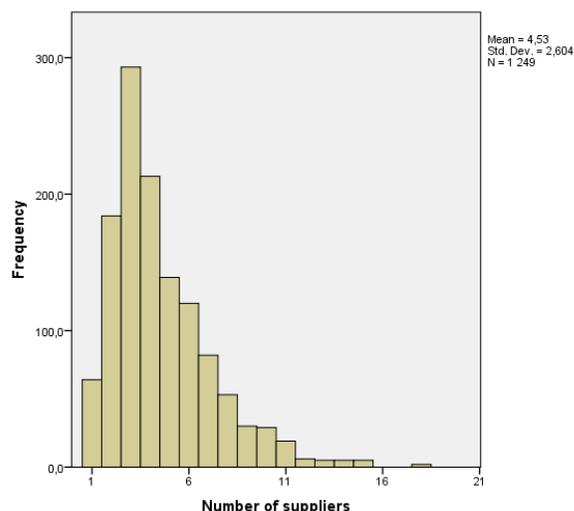


Figure 1 Number of suppliers: histogram

The *total value of the e-auction* is the value of the purchased product at the end of the e-auction (in other words, the best or the winning bid). The best offer is a good determinant of the value of the e-auction because it reflects current trends and conditions of the market as it was determined in direct competition between the potential suppliers.

The *size of the municipality* is derived from the number of inhabitants. The municipalities are divided into four categories (up to 20,000 inhabitants, 20–50 thousand inhabitants; 50–100 thousand inhabitants, more than 100,000 thousand inhabitants). This scale had to be used because some of the municipalities did not provide their name, only their classification within this scale. The other municipalities were then also divided into these categories. The number of e-auction cases per size category is shown in Table 2.

Table 2 Categories of items

Municipality Size	No. of cases
less than 20 thousand	493
20–50 thousand	385
50–100 thousand	107
more than 100 thousand	264

The variable *country* depicts whether the e-auction was held by a Czech or Slovak municipality. The assumption was that different legislative approaches could lead to different e-auction results.

Item category is the type of commodity or service procured. We used 24 categories of items, of which construction was the most common with more than 500 cases. The 10 highest categories are shown in Table 3.

Table 3 Categories of items

Category	No. of cases
Construction	585
IT	128
Groceries	92
Office Supplies	89
Furniture	52
Energy Supply	47
Cars	36
Printing	23
Hygiene Supplies	18
Regeneration of Vegetation	14
Cleaning Services	13
Equipment, machines	10
Others	142

The Kolmogorov-Smirnov test of normality was conducted for the quantitative variables (see Appendix 1). None of these variables were normally distributed (all $p < 0.05$). The standard statistical tests could not be used as all of the tests include the *savings based on estimated price* variable and thus non-parametric tests were used in the analysis instead. All of the statistical tests were done using the IBM SPSS Statistics 21 software.

3.2 Methods

Several statistical methods were used to analyse the dependence of the multivariate variables. The possibility of using a certain method is determined by its type, the size of the table (number of categories within observed variables) and the type of dependence (symmetrical or asymmetrical). In this study, several of these methods were used due to the different types of variables in the research.

To determine the dependence of the savings on *number of participants* and on *total value of the e-auction*, Spearman’s rank correlation coefficient was used. These variables are both quantitative and they do not fall within normal distribution. This coefficient is denoted with the Greek letter ρ (rho) and takes a value within the range $\langle -1 \text{ to } 1 \rangle$, where values -1 and 1 occur when the variables are perfect monotone functions of each other. The coefficient is computed as

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}, \tag{2}$$

where ρ is the value of the coefficient, d_i is the difference between the ranks of each observation for the two variables and n is the sample size.

For the analysis of dependence of savings on *size of municipality* and *item category*, the Kruskal-Wallis H test was chosen. According to Řezanková (2011), the null hypothesis of this test assumes that the medi-

ans of the dependent variable are the same within all categories, while the alternative hypothesis states that at least one of them is different. The Kruskal-Wallis test gives every value in the n_i sample its rank number. Then, the average rank \bar{R}_i is calculated, where $i = 1, 2, \dots, K$ (K is the number of samples, e.g. number of categories of the chosen variable). The Kruskal-Wallis statistic is then computed as

$$KW = \frac{12}{n \cdot (n+1)} \sum_{i=1}^K n_i \bar{R}_i^2 - 3 \cdot (n + 1). \tag{3}$$

However, this test establishes only the existence of dependence, not its direction or power. A post-hoc test must be executed to test these influences.

To test the dependence of savings on the *country* variable, the Mann-Whitney test was carried out for two independent samples (Czech and Slovak). This test is based on the Wilcoxon W statistic, where we again assign a rank to all the values from both samples and sum the values for both samples. The W statistic is then the smaller of the two values. The Mann-Whitney statistic is computed as

$$U = W - \frac{n_1(n_1+1)}{2}, \tag{4}$$

where n_i is the size of the smaller sample and W is the Wilcoxon statistic.

In both the Kruskal-Wallis and Mann-Whitney tests, comparison with the level of significance is needed to test the null hypothesis. A level of significance of 0.05 was chosen for this study.

If, based on the tests, it is concluded that the variables are dependent, it is possible to compute the power of this dependence with the coefficient η (eta). This coefficient takes values of $\langle 0 \text{ to } 1 \rangle$; $\eta=0$ represents the case of no dispersion among the means of the different categories and $\eta=1$ denotes dispersion within the categories. Following Řezanková (2011), the η coefficient is computed as

$$\eta_{Y|X} = \sqrt{\eta_{Y|X}^2} = \sqrt{\frac{\sum_{i=1}^R \frac{1}{n_i} \left(\sum_{j=1}^S n_{ij} y_j \right)^2 - \frac{1}{n} \left(\sum_{j=1}^S n_{+j} y_j \right)^2}{\sum_{j=1}^S n_{+j} y_j^2 - \frac{1}{n} \left(\sum_{j=1}^S n_{+j} y_j \right)^2}}, \tag{5}$$

where η^2 is the coefficient of determination, n is the sample size and y is the dependent (quantitative) variable.

4. Analysis of dependence of savings on chosen variables

In this part of the paper, the results of the analysis of the dependence of *savings based on estimated price* on the variables *number of participants*, *total value of the e-auction*, *size of municipality*, *item category* and *country* are presented.

4.1 Number of participants and total value of the e-auction

Spearman's rank correlation coefficient was used to establish whether the variables are dependent. According to the values in Table 4, the variable *savings based on estimated price* is dependent on both of these variables ($p < 0.05$). For the relationship between *number of participants* and *savings based on estimated price*, the coefficient is positive. This means that when more suppliers compete in the e-auction, the savings generally tend to be higher. It is presumed that the higher level of direct competition between the suppliers makes them more likely to lower the prices and the contractor gains higher savings.

The relationship between *savings based on estimated price* and *total value of the e-auction* appears to be negative (Spearman's rho lower than 0). This suggests that e-auctions of higher total value generally bring lower relative savings.

The relationship found between *number of participants* and *savings based on estimated price* is in line with the findings of existing research on e-auctions (Carter and Stevens, 2006; Pridavok and Delina, 2013; Pavel and Sicakova-Beblava, 2013). The value of the coefficient is around the same as in other studies (0.118 in Carter and Stevens; 0.38 in Pridavok and Delina). This might be caused by the different approach to data acquisition as this research is the only one of these studies that focuses on e-auctions undertaken solely by municipalities, not private companies.

The negative correlation between the value of the e-auction and savings is perhaps more surprising as other authors, such as Pridavok and Delina (2013), found that the relationship should be positive. In theory, it is presumed that competitors would fight for more lucrative contracts, which should lead to higher savings (this is, in fact, a very similar situation to that with the number of suppliers: a greater number of suppliers leads to a higher level of competitiveness). In this sample, the higher-valued auctions generally resulted in lower savings; however, the coefficient level of just -0.13 is quite low and the correlation is very small (0.06 in Pridavok and Delina). There could be a simple explanation for this anomaly, namely that

the most expensive contracts require specific suppliers, which have more bargaining power even in an e-auction.

4.2 Size of the municipality and country

The next tested variables concentrate on the characteristics of the municipality holding the e-auction. These parameters are size and country, i.e. where the municipality is located (Czech Republic or Slovakia). The Kruskal-Wallis or Mann-Whitney tests were used to determine the relationship, depending on the type of the variable. The η coefficient was then used to determine the strength of the dependence of the ordinal variable *size of municipality*.

It was concluded that the savings depend only on the size of the municipality ($p < 0.05$, see Table 4). Location seems to have no effect on the savings as the median is same for both countries. The different legislation in these countries seems to be irrelevant when it comes to savings, influencing only the volume of procurement cases done through e-auctions.

However, there is a low level of dependence of *savings based on estimated price* on the *size of municipality* as the η coefficient 0.1. This means that at least two medians for the categories are different from each other. Therefore, the size of the municipality has an influence on the savings gained in the auction. The direction of the dependence would have to be tested with post-hoc tests.

4.3 Item category

The last variable tested is the category of the item in the e-auction. The Kruskal-Wallis test was used and it was concluded that dependence exists ($p < 0.00$). However, it is not possible reach a conclusion on the power of the relationship as the variable *item category* is nominal and therefore not measurable using the η coefficient.

To establish which of the categories attain higher savings, a post-hoc test would again have to be used. In future research, it would be possible to determine whether the categories with higher savings are the same as those in which more suppliers compete or if there are some other unknown factors.

Table 4 Relationships between savings and chosen variables

Variable	Method used	Sig.	Correlation coeff./Eta coeff.
Number of participants	Spearman's rank correlation coeff.	0.00	0.28
Total value of the e-auction	Spearman's rank correlation coeff.	0.00	-0.13
Size of the municipality	Kruskal-Wallis test	0.01	0.10
Country	Mann-Whitney test	0.22	–
Item category	Kruskal-Wallis test	0.00	–

5. Conclusion

E-auctions are spreading quite quickly as a useful tool in the procurement process for both private companies and government organizations. The municipalities in the Czech Republic and Slovakia, which are the focus of this paper, are no exception to this trend. Aside from other benefits, e-auctions enable the contractor to attain relatively high financial savings in comparison to a procurement process with no direct competition on price. Therefore, it is valuable to analyse the variables that might influence the savings generated. In this paper, several of these variables have been examined: *number of participants*, *total value of the e-auction*, *size of the municipality* and *country*, and *item category*. It is found that all of these variables, with the exception of *country*, influence the savings gained in an e-auction. This is consistent with the findings of other studies in this field, again with one significant exception: in this paper, the variable *total value of the e-auction* is found to have a negative relationship with the *savings based on estimated price* variable. This is in contrast to other research. However, other studies usually find only a low level of positive correlation between these variables.

Municipalities which use e-auctions as part of their procurement process can therefore make assumptions concerning the results of their e-auctions based on the factors influencing it. For example, if they are procuring an item through process in which a high number of potential suppliers can be expected to participate, it is highly recommended to use an e-auction, as the direct competition has a positive effect on the savings generated.

In this paper, we have also set out some possibilities for further research, for example investigating whether larger municipalities tend to have better results than smaller ones, or which item categories tend to generate higher savings.

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Zákon č. 137/2006 Sb., o verejných zakázkách, ve znění pozdějších předpisů, s vyznačením navrhovaných změn a doplnění způsobených zákonem č. 55/2012 Sb., (zákon o veřejných zakázkách).

Appendix 1 – Normality test for quantitative variables

<i>Tests of Normality</i>						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Savings based on estimated price	.133	1172	.000	.872	1172	.000
Number of participants	.181	1172	.000	.889	1172	.000
Total value of the e-auction	.367	1172	.000	.285	1172	.000
a. Lilliefors Significance Correction						