Abstract. Electronic reverse auctions (eRA) have grown popular in the procurement communities recently. This trend is expected to continue as its benefits have been proved by the results in the companies across many fields. Their results depend on the actual market conditions while the literature emphasises the importance of the number of bidders in eRA for its result. In the paper, we present the evidence of the impact of competition among suppliers bidding within eRA on the efficiency of the tender, assessed via savings calculated as a difference between the Initial price and the Contract price. For this purpose, the method of correlation and regression analysis on the public procurement data provided by Electronic Contracting System has been applied. Moreover, we provide an analysis focused on a distinction between the savings caused by higher competition in goods and services, where our expectations of higher savings in services have been confirmed.

Keywords: Procurement; Competition; Electronic Reverse Auction; Savings; Slovak Republic

JEL Classification: H57; D44; Q55

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Effect of competition among suppliers on public procurement efficiency

1. Introduction and Brief Literature Review

Development of new technologies, and especially of those which are information and communication based, has affected all fields of industry in the developed countries [18]. A wide range of innovative solutions has been implemented and it has affected almost all aspects of doing business [2; 6; 9; 23] leading to the improvement of internal processes [4; 21-22]. Due to the increased efficiency, the application of information-communication technologies (ICT) in processes has become very popular both in private and public sectors [12; 19-20]. Thus, with such a change, there is natural to find electronic solutions to various problems in almost every field, including the pro-

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curement within supply chains [10]. ICT-based solutions play an important role in achieving the goals of procurement teams, enabling on-time supplies and popular among them is the electronic reverse auction (eRA) which is regarded today to be one of the most powerful negotiation mechanisms within electronic procurement. The rate of its use and popularity has been rising since its first application. This trend is expected to continue [3; 7; 15]. The eRA is described as an electronic sourcing method that builds a competitive and dynamic environment in which a number of suppliers compete against each other in real time to win a business [1]. Since the entire process is put into online environment, this method supports principles of transparency and speed if compared to traditional purchase methods [17].

Since the time the eRA was applied, there has been a discussion about the ways to increase savings and the aspects that affect this process. Generally, they are dependent on market conditions. Hence, if the conditions are favourable, the outcome of the auction will be positive too. We can also assume other impacts due to the literature based on previous research. Many authors emphasise that the number of bidders participating in the auction is a crucial indicator of supplier interest. In other words, the higher the number of suppliers is, the better [11; 13-14]. The importance of this factor raises significantly within the procurement process due to the auction, as in tenders, where each participant has the chance to submit only one bid and does not have information about the number of competing suppliers, this variable is not so important, however at the auction the price is dynamically pushed down through the competition of the individual suppliers whose aim is to outbid competitors. Some authors [16] argue that one supplier leads to poor outcomes; there are only mixed outcomes if there are two suppliers, whereas the best savings are attributed to a higher number of bidders. But we can also find opposite opinions. Some [3] provide evidence about auctions with only two suppliers, noting also that in such cases there is a high risk of loss of anonymity and a possibility that individual suppliers will recognise themselves. Most studies argue that at least three to five suppliers are required for successful auctions [3; 15] and the auction theory is in line with these statements [7; 25]. Others [24] provide a general statement that the auction should not be carried out if the number of suppliers is small.

2. Methodology

2.1 Research goals

Based on the previous findings, we have decided to support the evidence provision on the impact of competition among suppliers taking part within electronic reverse auctions on the savings which are calculated as the difference between the Initial price and the Contract price resulting from the tender. Our expectation says that, the higher the rate of competition is, the higher the percentage of savings calculated by using the Initial price and the Contract price should be. In contrast to the existing studies, we attempt to provide evidence on a recent sample from 2015 of public procurement data on commonly traded goods/services. According to the objectives of the research, we have formulated our own working hypothesis:

**Working hypothesis 1:** Higher competition among suppliers leads to higher savings within electronic reverse auction.

Moreover, as we possess the data of two different product categories - goods and services, we have analysed whether this distinction does have an impact on the latter relationship.

2.2 Data used

Our analysis is based on data provided by the Electronic Contracting System (ECS) in Slovakia. The ECS is a state-controlled centralised marketplace which can be used by different public bodies in order to procure products meeting specific criteria and price levels, while rights and obligations of these sub-jects are described in Slovak National Act on Public Procure-ment using electronic reverse auction mechanism for price ne-gotiation.

Before giving the main description of data, it is necessary to explain specific aspects of the database in use - the ECS, where the «common products» (goods or services) are procured. By this special category of products, the National Act understands the products which:

1. are not produced or provided on specific «tailormade» needs;
2. are sold in the form without major modifications of features;
3. are used to satisfy operational needs;
4. are consumable.

It should be mentioned that not only products are standardised but also agreements used for all procurements. We regard all of these attributes to be very beneficial for the purpose of our research, because the commonness of products ensures that there should be high competition within every tender and procurers do not have many options to hinder it. The planned analysis will be performed using the indicators presented in Table 1.

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID of procurement case</td>
<td>Each procurement case has specific ID number to enable its identification</td>
</tr>
<tr>
<td>Date of contract</td>
<td>Date when the contract between procurer and supplier was concluded</td>
</tr>
<tr>
<td>Number of competitors</td>
<td>Number describing how many competitors gave at least one bid within eRA</td>
</tr>
<tr>
<td>Number of bids</td>
<td>Number describing how many bids were received within eRA by all competitors</td>
</tr>
<tr>
<td>Initial price</td>
<td>The first bid in eRA in EUR</td>
</tr>
<tr>
<td>Savings</td>
<td>Relative savings (in %) comparing Initial and Contract (final) price</td>
</tr>
</tbody>
</table>

Source: Authors’ elaboration

2.3 Model specification

To achieve our objective, we will use the following linear regression model based on the panel data described in the previous section:

$$SAV_i = \beta_0 + \beta_1 IP + \beta_2 CLS_i + \beta_3 CLB_i,$$

where:
- $SAV_i$ - the value of Savings (in %) based on the result of eRA auction;
- $IP$ - the Initial price, so the first offer, within the eRA auction in EUR;
- $CLS_i$ - the value of Competition level based on number of suppliers;
- $CLB_i$ - the value of Competition level based on number of bids.

When creating the model, we needed to cope with the fact that the database also included the records of procurement cases where there was only 1 supplier. In such a case, the supplier had no motivation to change the price when no competitor occurs. As we did not want to remove these records, where there was only 1 bidding institution, we decided to adjust the variables describing the level of competition - (both the number of suppliers and the number of bids) by decreasing the original values by 1, which is the value of suppliers/bids.

New variables were calculated as:

$$CLS_i = \text{Number of competitors} - 1$$
$$CLB_i = \text{Number of bids} - 1$$

As previously stated, the impact of specification of the procured goods or services (quality, delivery and service conditions, etc.) should not be omitted. This parameter can influence the behaviour of both suppliers and procurers in either positive or negative way. However, when discussing the possibility to include this variable within the model, it is quite obvious that...
Before conducting the main regression analysis, we performed a correlation analysis using the non-parametric Spearman correlation coefficient. We found a strong correlation between a few pairs of variables, such as Competition_level_SUPPLIERS and Savings_per, which indicated that our prediction about the strong relationship would be proved. High is also the level of correlation between Competition_level_BIDS and Savings_per was also high. The same was for the Competition_level_SUPPLIERS and Competition_level_BIDS variables.

4. Results

As mentioned before, the main method for our research with the goal to define the relations between the competition price and the contract price was a linear regression based on the panel data.

The model equation according to the result of regression analysis is (Table 3):

\[
SAV_i = 4.165 - 3.383E^{-5}P_i + 2.852CL_i + 0.134CLB_i
\]

The dependent variable was Savings and the independent variables were represented by Initial price and factors of competition. The values of the beta coefficients and the significance of concrete input factors are listed in the table below.

When comparing the results with our expectations, we can conclude that our predictions were correct as:

- Initial price - negative relation (-3.383E-5)
- Competition level based on the number of suppliers - positive relation (3.252)
- Competition level based on the number of bids - positive relation coefficient (0.134)

As expected, the effect of competition is positive. As can be seen from equation 4, each new competitor will mean that contract savings will increase for about approximately 2.852% and each bid will increase the savings by more than approximately 0.134%. On the other hand, the initial price has a negative impact on auction savings even if the opposite result is expected. However, it should be mentioned that this influence is very insignificant (-3.383E-5). In other words, the price movement in the electronic reverse auction is mostly related only to the level of competition and suppliers. This can be explained in following way - the effect of procurement attractiveness perceived by suppliers according to the value of procurement is automatically present in the competition level among the suppliers.

In order to find some differences between savings when procuring goods vs. services, we conducted the same analysis for both of them. As can be seen from Tables 4 and 5, the biggest difference in the case of goods and services the level of competition was 2.7% (similar to the case of the whole sample). Other variables - the initial price and the competitive level on bids (the number of suppliers taking part in the eRA) where, in the case of services, each supplier in the competition brings about approximately 3.5% of savings, whereas in the case of goods it is 2.7% (similar to the case of the whole sample). Other variables - the initial price and the competitive level on bids (the number of bids) did not show any obvious differences. These findings related to the number of suppliers emanate from the fact that the cost of goods is determined by their production cost and some other costs related to them (transport, package, etc.). However, the cost of services is often given by the variable costs depending mainly on the salary of employees or subcontractors, so their assessing is more complicated and subjective. For the purpose of this work, we applied the Kolmogorov-Smirnov test of normality. The result of test indicated that the data were not normally distributed.

### Table 2: Description of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Var</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition_level_BIDS</td>
<td>543</td>
<td>0</td>
<td>543</td>
<td>214.539</td>
<td>24.26</td>
<td>38.43</td>
</tr>
<tr>
<td>Competition_level_SUPPLIERS</td>
<td>19</td>
<td>0</td>
<td>19</td>
<td>23.284</td>
<td>2.63</td>
<td>2.621</td>
</tr>
<tr>
<td>Initial_price</td>
<td>361375</td>
<td>2.0</td>
<td>361377</td>
<td>73,802,002.5</td>
<td>8,346.9</td>
<td>26,207.6</td>
</tr>
<tr>
<td>Number_bids</td>
<td>543</td>
<td>1</td>
<td>544</td>
<td>223,381</td>
<td>25.26</td>
<td>38.4</td>
</tr>
<tr>
<td>Number_competitors</td>
<td>19</td>
<td>1</td>
<td>20</td>
<td>32,126</td>
<td>3.63</td>
<td>2.6</td>
</tr>
<tr>
<td>Object_of_contract</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>16,631</td>
<td>1.88</td>
<td>1.188</td>
</tr>
</tbody>
</table>

Source: Authors’ elaboration
Finally, we have investigated the overall significance and the performance of the model. As we can see in Table 7, the Coefficient of determination (R-squared) is at the level of 0.594, which means that almost 60% of savings is based on the three factors studied in this article. In other words, almost 60% of variability is described by the proposed model. Thus, we can see that the proposed model is statistically significant.

5. Conclusions
The purpose of this paper was to verify the impact of competition among suppliers taking part within electronic reverse auctions on the saving in the Slovak public procurement environment. Based on the results obtained from the data generated by the Electronic Contacting System, we can say that the higher the number of suppliers and bids in the eRA is, the higher is the pressure on the suppliers to lower their prices down to the real market prices, which will lead to higher savings. Consequently, we have confirmed our expectations based on the previous studies conducted by [3; 15-16].

Nevertheless, our second expectation related to the initial price, when we expected that a higher initial price would lead to higher savings, did not prove to be true. However, with a higher initial price, the final savings were a bit lower and the effect of procurement attractiveness perceived by the suppliers according to the value of procurement was automatically present at the level of competition among the suppliers. Finally, in order to find some differences between variables affecting the final saving between services and goods, we have found out that in the case of services a probably increase in the number of suppliers brings higher savings if compared to the case of goods.

However, for future research, it would be interesting to understand how stable this relationship is over time and what can be analysed further. Also, the impact of other procurement process settings on its result should be investigated more deeply [5; 8]. On the other hand, some questions will probably remain open due to limited access to the relevant data.
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References


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