

# Electronic Reverse Auctions in Public Sector Construction Procurement: Case Study of Czech Buyers and Suppliers

Tomáš Hanák<sup>1</sup>

<sup>1</sup>*Brno University of Technology, Faculty of Civil Engineering, Veveří 95, 602 00 Brno, Czech Republic*

**Abstract** – This paper examines the public sector adoption of the new technology of real-time electronic reverse auctions (e-RA) in construction procurement. Qualitative research was conducted to examine the experiences, opinions and attitudes of both buyers and suppliers to e-RA through semi-structured interviews. It was concluded that when certain principles and limitations are respected, e-RA can be used successfully for the acquisition of goods, services and works related to construction by public procurement. The knowledge gained through the research was transformed into recommendations to help buyers handle e-RA in the construction sector appropriately.

**Keywords** – construction industry, electronic reverse auction, public procurement, savings, transparency

## 1. Introduction

The construction industry has unique aspects resulting from the stationary nature of the product, the mobility of production resources, material, employees and machinery, high time and resource demands, a high level of uncertainty, an actual price exceeding award price and a high number of stakeholders in the construction project that need to be managed adequately [1]. It is also typical that construction companies are quite slow in adopting IT and innovative approaches [2], e.g. authors in [3]

argue that practitioners mainly rely on traditional work practices and a survey of KMPG [4] shows that the construction industry is still not taking full advantage of new technologies. This is an obstacle for performance improvement, for without adoption of new technologies it is impossible to achieve the best performance [5].

However, due to increasing competition, companies are forced to search for economical solutions to help them perform more efficiently. Public institutions are also required to use public finance efficiently, in the context of the 3E principle (Economy, Efficiency, Effectiveness) [6]. Purchasing management is one of the basic processes that have impact on the success of the institution; it is even considered a tool that can bring actual competitive advantage [7] to an institution (“buyer”). Nowadays, efficiency is closely linked to the use of information technologies, and the automation of the purchase process is therefore one of the key areas of current research in purchase management [7], [8].

One of the possible ways to computerize institutional purchases is the adoption of electronic reverse auctions, which have become a popular tool for achieving cost savings during the last decade. Electronic reverse auctions (e-RA, also called online reverse auctions) are real-time online dynamic auctions that take place between the buyer and a group of 2 or more suppliers who compete with each other to win contract for the supply of goods or services (adapted from [9]). In practice, auction systems are used in various economic sectors, but how suitable they are and how efficiently they are used depends on the specifics of the environment in which they are applied. The construction industry is one of the sectors where the use of auctions is largely controversial, which may result, for example, in the unwillingness of the suppliers to participate in auctions [10].

Given this controversial environment that makes the construction industry a polarizing example, this study examines the application of e-RA in this sector, focusing on public procurement. Since this topic has not yet been subject to systematic study and only limited literature is available (also due to the scarcity

---

DOI: 10.18421/TEM71-06


<https://dx.doi.org/10.18421/TEM71-06>

**Corresponding author:** Tomáš Hanák,  
*Brno University of Technology, Faculty of Civil Engineering, Veveří 95, 602 00 Brno, Czech Republic*  
**Email:** [hanak.t@fce.vutbr.cz](mailto:hanak.t@fce.vutbr.cz)

*Received: 01 November 2017.*

*Accepted: 23 January 2018.*

*Published: 23 February 2018.*

 © 2018 Tomáš Hanák; published by UIKTEN. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 License.

The article is published with Open Access at [www.temjournal.com](http://www.temjournal.com)

of suitable datasets on e-RA construction [11]), this paper aims to bridge the gap in the existing knowledge and provide a comprehensive insight into this area.

This research focuses on the adoption of e-RA by buyers, evaluates the suitability of e-RA for the acquisition of goods, services and works related to construction by public procurement and provides buyers with recommendations for appropriate handling of the e-RA. The research mainly addresses key e-RA inputs and outputs from the perspective of the construction project. The Czech Republic was selected as a study area, but in relation to joint EU legislation on public procurement, the results of this paper could be applied also in other European countries, especially in the countries of central and south-east Europe that have undergone a similar transformation after 1989.

The structure of the paper is as follows: it starts with a comprehensive literature review focused on e-RA adoption/applicability, outcomes, ethical questions and purchasing related to the nature of the construction sector. Next, the paper introduces research questions and presents research methodology. The data gained by qualitative research is then discussed and used as a basis to formulate recommendations for appropriate handling of the e-RA in the construction sector.

## 2. e-RA adoption and outcomes

Contemporary data reveals poor utilization of e-procurement and e-RA in construction. This has been documented e.g. for Austria [12] or the Czech Republic, where just 0.036% of public works tenders used e-RA [13]. At the European level, auctions are used infrequently (less than 1% in terms of number and volume of contracts awarded [14]); in Portugal, e-RA took place in 0.7% of the tenders [15]. The above-cited data shows that there is still a significant potential for more widespread use of e-RA.

Support for decision-making on the use of auctions has been proposed in the “e-RA Appropriateness Model” [16], while other approaches were developed, for example, in [17], [18] or [19]. The concepts developed in [16] and [20] are addressing the following joint substantial features: relationships between suppliers and buyers, the existence of suitable suppliers, costs related to the auctions and the choice of the auction system.

Regarding the suitability of the purchased product for auction, some authors assume that low risk products are suitable for auctions – these apply e.g. to the standardized products [21], but there is also a contrary opinion that even complex purchases can be successfully implemented through e-RA, if they are clearly specified and interpreted in the same way by the buyer and the supplier [19]. It is not only the nature of the demanded products that is important in this respect, but also the amount that is demanded [22]. If the buyer is unable to request a sufficiently attractive volume of the product, he may struggle with a lack of suppliers willing to participate in an auction. In this relation, Tkac et al. [23] concluded that an unattractive contract is the second main reason for a company to reject a request for a proposal in the construction sector. However, if suppliers do not have sufficient capacity to meet the buyer’s demand individually, a winner-take-all auction cannot be organized [24].

The excess of supply over demand is a strong incentive to use an auction for purchasing; in other words, the economic situation also partially influences the appropriateness of an auction (suppliers will be more willing to participate in auctions during a recession than during a period of economic upswing, [18]). On the basis of the studies that have been published so far, the following key prerequisites for successful use of e-RA are listed (Table 1.).

Table 1. Summary of key prerequisites for successful use of e-RA

Prerequisite	Effect
The product in demand can be specified in a clear and comprehensible way	Determination of the e-RA suitability for commodities purchased
There is a high probability that the current price is significantly higher than the market price	e-RA has the potential to bring financial benefits
The costs of auction implementation and change of supplier are acceptable	
There are suitable conditions in the supply market (i.e. enough qualified suppliers with qualified staff to participate in an auction)	Interest of suppliers in participating and the creation of a competitive environment in the tender
The demanded volume (contract value) is sufficiently attractive	
It is made possible for the suppliers to achieve production efficiency	Avoidance of technical and other problems in use e-RA can be managed appropriately
The buyer uses high-quality auction software	
The purchasing staff is sufficiently trained in the use of e-RA	
The setup of the auction is clear and supports transparency	Adequate communication and trust in tender

It is therefore necessary that buyers provide suppliers with detailed information about the rules of the game [25] so that they can understand the process [26]. Accuracy, clarity and open communication between the buyer and the suppliers are the basic prerequisites for the success of the auction [27].

The readiness of the staff must be ensured not only on the part of the suppliers, but also on the part of the buyer [28]. The user must be familiar with the options for the set-up of the auction and their impact on the process and outcome of the purchase. Training by the system operator and supervision of the preparation and implementation of several initial auctions should be a matter of course.

From the buyer's perspective, reduction of bid price is among the key benefits of auctions. The probability of achieving greater savings increases with the level of competitiveness of the auction as measured by the number of bids [29] and higher savings can also be expected in regard to the phase of the economic cycle [30]. It could be of particular interest for a buyer to be able to estimate the number of bidders in a future/upcoming auction [31], as a positive correlation exists between the number of submitted bids and the award price [32]. Enhanced transparency, time savings and elimination of geographical and spatial barriers are also seen as important benefits [33], [34], [35]. A very sensitive topic for discussion is whether lower price comes with lower quality of the purchased items as price and quality are conflicting attributes [36]. Love and Li [37] claim that failure with regard to quality has become an endemic trait of public sector construction procurement, leading to exceeding costs and missing the deadlines in projects. Shortcomings in the quality of a structure are hidden costs, which are difficult to measure, but which are nevertheless real and significant in volume [38]; for this reason, the issue of quality is an important one in the construction sector. The study of Lin and Kong [39] has shown that in public construction projects, the award price correlates with the quality of delivery.

The benefits on the part of the suppliers are not as marked as on the part of the buyers, but suppliers can also profit from auctions, especially by gaining equal conditions for negotiation [33] or by gaining information about market prices [34] which can help them check their competitiveness. As opposed to other benefits (such as decrease in bid price), enhanced transparency of the tender can be viewed as significant even by the suppliers [33], as e-RA provide them with an equal opportunity to win the contract.

In general, suppliers perceive e-RA considerably more negatively than buyers as they are afraid of the adverse effects of e-RA on their overall performance

[40]. The main reasons for their largely negative view of e-RA are an expected decrease in bid price, exposure to a large number of competitors and the need for the purchasing staff to acquire new IT skills relating to the use of particular SW if there is no previous experience. This often results in the unwillingness of suppliers to participate in auctions [10]. Authors in [41] indicate that only a small proportion of suppliers have a positive view of auctions, seeing them mainly as an opportunity to win a contract and not as a threat.

In connection with e-RA, it is sometimes mentioned that auctions may harm the business relationship between the supplier and the buyer [21], this effect is severe especially in a limited supplier base [42]. Severe detrimental effect the relationship emerges if a large bid price decrement over the course of e-RA is reported [43]. However, auctions may have also a positive impact on the trust between the supplier and the buyer due to the transparency and objectivity of the process [9].

Several studies conclude that instances of unethical behavior appear in e-RA, on the side of both buyers and suppliers, especially in the form of running an e-RA without the intent of awarding business, collusion of suppliers [9], awarding contracts more often to incumbents [44], submission of abnormally low bids [45] or delivery of lower quality products/works.

The trust in auction can be negatively influenced by technical problems, rumors [46] or an inadequate auction format. It is therefore important that buyers run e-RA in a fair manner, which requires clear explanation and communication of non-discriminatory auction rules and conditions [34] to suppliers. Therefore, due attention should be paid to the settings of the auction, such as bid visibility [47], [48] number of tendered items, the options for decreasing bids or the way the bids are evaluated (that is, the choice of evaluation criteria and their weights [49]).

### **3. Purchasing management in construction and public procurement**

Public procurement must be transparent and it is therefore crucial to ensure an open process to select the winner [50]. Various supplier selection methods can be applied in practice; however, as revealed in [51], price-to-quality scoring and lowest price are the most common. In this relation, it should be noted that quality affects the life cycle costs of products/projects and that service quality is dependent on the quality of the supplier's performance [52].

Public authorities should also be aware that maximizing the number of bidders does not always lead to minimizing costs and invite a reasonable, but not unduly large number of suppliers to the tender [53]. The size of the company can serve as a limiting factor, as overly prescriptive requirements or prohibitive resource requirements associated with preparing bids, e.g. cost and time, among others, can limit SME involvement in public procurement [54].

Production in the construction sector differs from other types of industrial production by a number of specific features, as mentioned in section 1. The final product of construction production is a unique fixed asset. Its unique nature is given by the fact that the location of each structure is unique and that each structure has unique project documentation (this is why the use of e-RA in construction for straight rebuy situations is very limited).

Defining qualitative requirements for product delivery may be difficult: for example, the Czech Public Procurement Act [55] does not allow buyers to specify materials by their name or manufacturer. Built structures can also have hidden defects that might not be uncovered at the time when the finished structure is handed over to the user or during the warranty period. This results in higher structure life-cycle costs for the buyer.

Another specific features related to purchasing in construction are (1) high level of outsourcing [56], as many companies do not have the capacity or equipment to perform all the contracted works themselves; (2) good communication becomes critical due to the involvement of many project stakeholders [57]; and (3) there are frequent changes during the implementation of the projects, which results in cost and time overruns [58], [59] – in this context, some buyers tend to use traditional clauses such as price index formulas, however, as discussed in [60], they do not generally result in an optimal situation.

An important condition for the success of an auction is proper qualification of the suppliers, which increases the probability that the supplier will be able to finish the project successfully. There are a number of methods that can be used within construction projects [61], [62], [63], though their use in the public sector may be limited by the legislation in force.

Having in mind that construction projects are becoming more complex and difficult to manage [1], that they involve a high level of uncertainty and that the actual price mostly exceeds the award price (as the real total costs of construction are not known in advance), the use of e-RA seems debatable. Cost planners therefore call for more details in the design stage to achieve more realistic cost estimates [64] in

order to improve construction performance in term of economic aspect [65].

The suitability of auctions with regard to the character of the purchased product does not need to be examined only from the point of view of sufficient specificity of the demanded products, but also from the point of view of potential competition in the auction. For example, it has been proved that there is a difference between the number of bids in the case of public procurement of public buildings and facilities and public procurement of transport infrastructure, which has an impact on the amount of achieved savings [66]. Similar differences in competition among contracts are corroborated e.g. in [67].

The problematic nature of auctions in construction contracts is reflected also in the legislation of the Slovak Republic. The Public Procurement Act [68] that was in force between 1 January 2012 and 31 December 2012 made it mandatory for the buyers in open tenders and restricted or negotiated procedures with publication of a contract notice to use an electronic auction for the delivery of goods; but in the case of delivery of services and construction works, auctions could only be used if it was possible to clearly specify the technical requirements of the subject of the purchase. Any legislation stipulating mandatory use of e-RA must therefore take into account whether the subject of the auction can be clearly specified. However, there is no clear-cut line between situations where technical requirements for the subject of the auction can be clearly specified and those where they cannot.

With view to the above-mentioned complexity and high level of risk of construction projects that have an impact on the preparation of project documentation, on the choice of supplier and other decisions, it seems desirable to examine the suitability of auctions and their proper use in a project-oriented industry, such as the construction industry.

#### 4. Research questions

The literature review identified important aspects related to substantiated adoption and correct use of e-RA. With regard to the construction industry, it seems important to examine especially the suitability of products for auctions, quality of the deliveries, participation of suppliers in the auction, increase in efficiency of the purchase process related to its potential automation and application of appropriate auction rules and conditions. The three research questions below were developed within this context.

RQ1: What types of goods, services and works related to the delivery of a structure over its life cycle are suitable for auction?

If an auction is to succeed, it must be possible to specify clearly the subject of purchase. However, it is disputed whether all types of goods, services and works related to the delivery of a structure over its entire life cycle can be considered suitable for e-RA. Therefore, the first research question focuses on the applicability of e-RA in the construction sector with the aim of clarifying the appropriateness of various items for purchase.

RQ2: Do buyers and suppliers perceive the relation between reduction of bid price and quality of the product differently?

As the positive outcomes of e-RA are mainly apparent on the side of the buyer, comparing the perspectives of both sides (buyers and suppliers) on

e-RA outcomes should be of particular interest. Crucial variables related to the delivery of construction projects are price and quality, as well as their mutual relationship, as it is argued that a decrease in bid price causes a drop in quality. Therefore, the second research question addresses the interaction of these two e-RA outcomes.

RQ3: Are both buyers and suppliers aware of what e-RA settings are needed to ensure procedural fairness?

If e-RA is to be used in a procedurally fair way, it must be supported by adequate settings of auction rules and conditions. The third research question therefore explores whether both buyers and suppliers understand the effects of these rules and conditions and are aware of possible pitfalls.

The research topics, related key points and objectives of this study are presented in Table 2.

Table 2. Key points and objectives of study with related supporting e-RA research

Topic	Key point	Objective
e-RA adoption and applicability	<ul style="list-style-type: none"> <li>• Motivation of buyers to use e-RA [21]</li> <li>• Attitude of suppliers to the use of e-RA [33]</li> <li>• Suitability of goods/services/works for e-RA [19], [21]</li> </ul>	To identify specific aspects and phenomena related to the adoption, use and suitability of e-RA in the construction industry
e-RA outcomes	<ul style="list-style-type: none"> <li>• The award price – quality relationship [34]</li> <li>• Potential of purchasing automation [69]</li> <li>• Buyer-supplier relationship [21], [27]</li> </ul>	To elucidate e-RA outcomes arising out of the application of auction in construction sector
e-RA ethics and procedural fairness	<ul style="list-style-type: none"> <li>• Auction rules and conditions [47], [48]</li> <li>• Ethical misconduct [44]</li> </ul>	To provide procedural suggestions for clear and transparent use of e-RA

## 5. Research methodology

To achieve the research objectives (Table 2.), it was desirable to learn the opinions and attitudes of the current e-RA users both on the part of the buyers and on the part of the suppliers and to identify similarities and differences between them. In order to enrich the research by bringing in another view, a third group of respondents – those who do not currently use e-RA – was interviewed in order to investigate the differences in their attitudes towards e-RA compared to the e-RA users. In the case of nonusers, the interview focused on expectations rather than experience with e-RA. In this context, the respondents were divided into three groups: 1) current e-RA buyers, 2) current e-RA suppliers and 3) e-RA nonusers (both buyers and suppliers together). The research was conducted in the Czech Republic, where legislation [55] makes it possible to use auctions for public procurement. The Czech Republic is arguably a good case country, since its national legislation is influenced by the EU regulations and the results of this research may therefore be applicable to other EU countries. From

this perspective, this research contributes to substantial extension of knowledge, particularly in the region of central and south-east Europe. The research comprised three separate topics (Table 2.).

Separate in-depth interviews were prepared for all three groups of respondents; the initial versions of the interviews were first tested on test respondents and then adjusted for the final version. The data was collected between 2014 and 2016 during physical meetings (only in one case was data collected over the telephone) with the representatives of selected buyers and suppliers who deal with e-RA as a part of their jobs, i.e. who are responsible for purchasing in their institutions (buyers) or are responsible for the submission of bids and participation in tenders (suppliers). These prerequisites were set to ensure the professional eligibility of the individual persons for the interviews. In the case of e-RA nonusers, it was required that the interviewed person be in a position to influence the decision on potential e-RA adoption. Altogether, 16 interviews were conducted; every interview was processed in writing and sent to the respondent for verification of the content correctness.

The average length of an individual interview was 80 minutes.

Primary data (transcripts of the interviews) was analyzed by using thematic analysis. Altogether, 16 respondents participated in the qualitative research; 8 of them in the category of e-RA buyers, 4 in the category of e-RA suppliers and 4 in the category of e-RA nonusers (2 buyers and 2 suppliers). Because buyers are the initiators of e-RA adoption, there are more buyers in the sample than suppliers. In order to obtain a wide range of views on e-RA, all of the respondents were from different public institutions (buyers) and construction companies (suppliers).

## 6. Results

The adoption of auctions by public authorities was usually initiated by the local administration (2 respondents chose not to answer this question). It must be noted that the adoption of auctions in the public sector is largely a political decision, so the support of local administration (board or council/management) is inevitable. Main findings related to the adoption and applicability of e-RA are the following:

- system acquisition by purchasing a license enabling remote access,
- cost savings and enhanced transparency were main reasons for adoption,
- conflicting opinions regarding the suitability of e-RA for various subjects of purchase (design documentation, services, building maintenance),

- use of bottom limit for the use of e-RA (that is tenders of a very low value such as up to EUR 1,850 or 7,400) are not put out to tender using an auction,
- low computer literacy of small suppliers has been experienced,
- technical problems related to the first entering the e-RA (correct Java or browser settings on the part of suppliers), missing electronic signature.

It was interesting to find that all four e-RA nonusers have discussed the possibility of using e-RA. From the perspective of nonuser buyers, the decision to reject the adoption of e-RA was their assessment of potential savings as insufficient when compared to the acquisition costs, as the respondents perceive only a limited use of e-RA (such as purchase of electric energy or office supplies). Nonuser buyers have no clear idea of how to use auctions for public works contracts and which subjects of purchase relating to construction are suitable for e-RA. On the side of nonuser suppliers, a negative attitude towards e-RA adoption is related to the expected e-RA outputs. Although auctions were considered technically suitable for construction contracts, it has been mentioned that if a company is able to fill production capacity by contracts obtained outside an auction, there is no reason to participate in e-RA as the profitability of the business is preferred. It must be noted that the answers of e-RA nonusers were surmises and feelings rather than substantiated assertions based on compelling reasons, which indicates a very low awareness among them about the appropriateness of auctions in construction.

Table 3. Identified e-RA outcomes by e-RA users

Buyers	Suppliers
Benefits: cost savings (reported of between 8 and 30%), transparency, quicker and efficient communication, participation of bidders from other regions and reduction of administrative burden. e-RA may help automate the purchase process. When the buyer regularly (winter sidewalk maintenance, review of fire-fighting equipment) or irregularly (installation of new windows, apartment renovation) awards the same contracts. Buyers agree that auctions do not cause a drop in quality in the case of tenders for construction projects.	Procurement process is not more transparent in comparison with traditional procurement process, excessive drop in prices. Higher work load (preparation of bids in both electronic and printed form, the need to adjust itemized budget in the event of winning the contract). More prolonged procurement procedure. Drop in quality can be observed.

Findings relating to e-RA outcomes are given in Table 3. Data clearly shows how current e-RA users perceive differently the effects of auctions, especially in the context of price and quality. Nonuser buyers assume that auctions have a positive impact on the transparency of the process and they also believe that financial savings can be achieved through e-RA. However, respondents are worried about a decrease in the number of bidders and in quality. Nonuser suppliers expect a substantial decrease of bid prices as

a crucial negative factor. It was noted that an extremely low resulting award price in e-RA deforms the market and that it must be reflected in a reduced quality of the supplier's performance. Furthermore, they claim that e-RA are more time-demanding than traditional procurement. However, one respondent also mentioned a positive aspect, namely the enhanced transparency of the tender and equal opportunity to win the contract. Overall, with regard to the emphasis

on the financial aspect of the matter, nonuser suppliers consider e-RA outcomes to be negative for them.

Main aspects relating to the ethical questions and procedural fairness are given in Table 4. Both current buyers and suppliers did not report any instance of unethical behaviour. Despite from the e-RA users, all

four e-RA nonusers answered the questions related to the auction settings in a very vague manner. It can therefore be concluded that they are not familiar with the details of how auctions actually work, what parameters must be set and what must be done during the preparation of the tender.

Table 4. Main aspects of ethical questions and procedural fairness mentioned by e-RA users

Buyers	Suppliers
User training and customer support were used when implementing first auctions.	No instance of unethical behaviour has been reported.
Current best price is made visible during e-RA, usually with current ranking	The requirement to make the lowest bid price visible was acknowledged.
The length of one bidding round is usually set to 15, 20 or 30 minutes and if a new lowest bid appears during the last 2 (or 5) minutes, the round is automatically prolonged.	Using an auction cannot prevent potential deliberate manipulation through the settings of the qualification criteria or evaluation criteria.
An auction usually has one winner who enters into a contract for the work done with the buyer.	Duration of bidding round of 10 or 15 minutes is sufficient.
Usually, the auction only includes one item (that is, the bidder only enters one value) for the entire structure. If the contract consists of multiple structures (such as a sewer system, road and street lighting), it may have as many items as there are structures.	Training is not considered to be necessary.

### 7. Relationships between inputs and outputs of auctions in the construction industry

The analysis of the interviews identified important connections between auction inputs and outputs that can be seen in relation to the purchase of goods, services or works related to a structure. The most often cited aspects are the suitability of the subject of purchase for auction, the amount demanded and auction rules and conditions on the part of inputs and

quality, achieving financial savings, process transparency and time savings on the part of the outputs. The nature of the purchasing situation and the number of bidders are also significant in this respect. The relationships among these factors are shown in Figure 1.

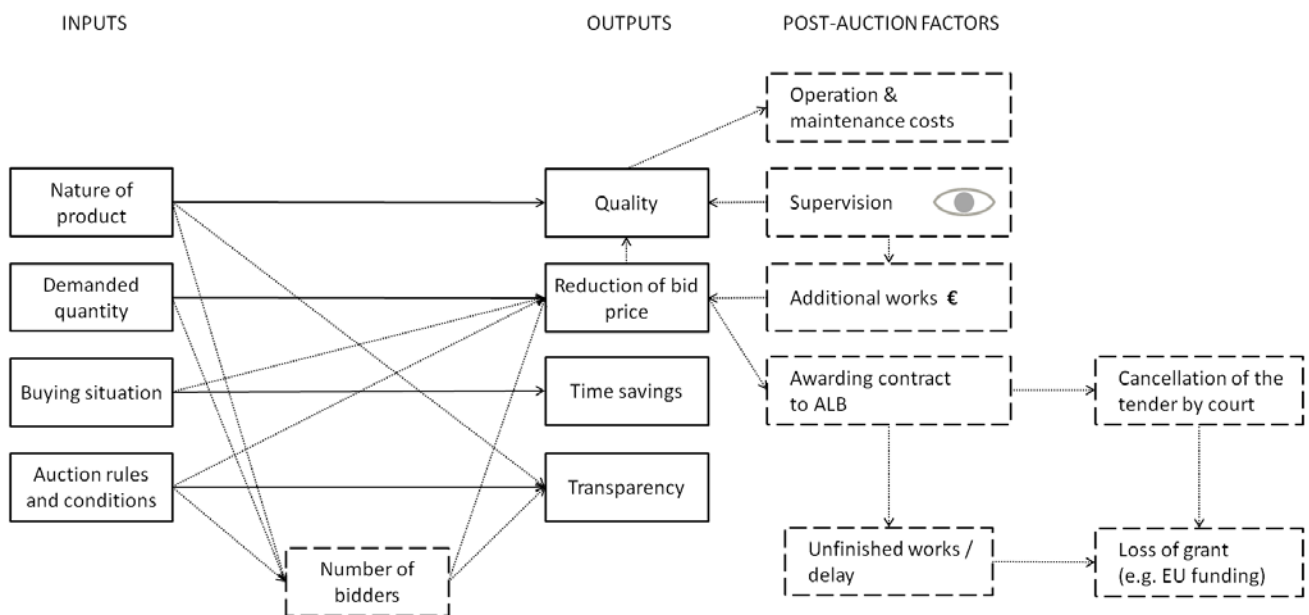


Figure 1. Model of relationships between e-RA inputs, outputs and post-auction effects in the context of the construction sector

The requirement of product specifiability is important, because it allows the buyer to set clear quality requirements and subsequently verify that the delivery meets these requirements and also because it influences the number of participants in the tender. A sufficiently attractive volume demanded has a positive impact on the number of bidders and on the attainable financial savings, as it is possible to achieve a larger discount for a larger purchase. The nature of the purchasing situation influences mainly the attainability of time savings and the volume of savings (straight rebuy/new task). Finally, auction rules and conditions are essential to ensure the transparency of the process; as such, they may also influence the number of bids in the tender. The number of bidders is a mediating variable with a significant impact on the reduction of bid price and the transparency of the process (the higher the number of bidders, the lower the probability of impact of any collusion of suppliers).

The research findings did not confirm that e-RA lead to a decrease in the number of bidders for the contract in the tender, which is a very important finding. Even though buyers note that some suppliers do not participate in auctions (primarily very small suppliers), they also add that these suppliers have been replaced by others.

An important aspect of the use of e-RA within the construction industry is the influence of post-auction factors. Reduction of bid price is a specific phenomenon, as it is an output of the auction that may affect the quality of deliveries during construction (if the price is too low). A drop in quality will have a negative effect on future operation costs, but it might not be visible at first sight as it may be related to

## 8. Recommendations for appropriate handling of e-RA

On the basis of the conducted review of the literature and the results of the qualitative research, the following recommendations for buyers were formulated to help them handle e-RA in the construction sector appropriately. The first part of these recommendations belongs to e-RA adoption and applicability (points 1–4), the second part to e-RA outcomes (5–8) and the third part to e-RA ethics and procedural fairness (9–12).

1. The suitability of a product must be viewed primarily within the context of two factors: whether the product can be clearly specified and to what extent it is intellectual property.
2. Checking the rules of granting authority regarding e-RA use if the given project is sponsored by a grant.
3. The decision on e-RA adoption should be purely rational.

defects that are hidden below the surface. Therefore, it is in the buyer's interest to supervise compliance with quality requirements and it is pivotal that the entire construction preparation and implementation process is supervised.

Moreover, award price does not equal actual price. These disparities are caused mostly by additional works, changes in the project or construction time overruns. In this context, it should be noted that the role of supervision is to monitor not only the quality of the works, but also the amount of the works done. In this way, the buyer can avoid paying for additional works that were not performed or were performed on a smaller scale than reported. This risk seems to be the highest in contracts involving a greater range of earthworks or renovation of historical buildings.

Of all the outputs listed in Figure 1., only the reduction of bid price (with regard to the award price), time savings and transparency outputs can be evaluated immediately after the auction has finished. The actual price can only be assessed when the final bill for works is approved by the buyer. Also, the quality needs to be monitored during the whole construction process (supervision) and evaluated only when the products are delivered, the structure handed over or the test run finished (in the case of a complicated contract, this could take several years, thus significantly hindering any effort to evaluate the impact of the auction).

Figure 1. also shows the effects on future operation and maintenance costs and the consequences of awarding the contract to ALT, which can result, for example, in the loss of external funding (grants).

4. Choosing a quality auction system is crucial (with a focus on comprehensive user support and training being offered and the experience of the provider with implementation of auctions related to contracts from the construction sector).
5. In the case of delivery of construction works, it should be standard procedure to hire a supervisor who will be present at the construction site and continuously monitor the quality.
6. Balanced qualification prerequisites should be set with a view of allowing only properly qualified suppliers to participate and to create a competitive environment.
7. The potential amount of financial savings depends on a number of factors (phase of the economic cycle, goodwill of the customer, attractiveness of the demand, pool of suppliers).
8. Choice of evaluation criteria e.g. in relation to taking total life-cycle costs of a structure into account.
9. The buyer must check whether the winning bid price is not an abnormally low bid price.



10. Tender documentation should include a provision which mandates proportional decrease of the itemized budget by the coefficient that corresponds to the difference between the initial and final bid prices.
11. Open communication with suppliers and asking for feedback create a more positive attitude towards auctions on the part of the suppliers.
12. Creation of internal regulation governing institutional purchases based on best practices.

As regards point 10, such a provision is crucial to avoid the risk that the winning supplier will not lower the price for items where additional works may be expected, which could actually compensate for his decreased contract margin. The buyers should also take into account that it is not desirable to change the items that include fixed costs (such as the costs of bank guarantees), which should therefore be excluded from the requirement for a proportional decrease.

## 9. Conclusion

This paper focused on the specific features of the use of e-RA in the construction sector, in particular in public sector construction procurement, with the objectives of assessing the suitability of e-RA for the procurement of goods, services and works, elucidating the e-RA outputs and providing buyers with recommendations for appropriate handling of e-RA. The main findings presented in this paper should arguably be valid also for other EU countries, since public procurement is subject to common EU legislation.

The objective of RQ1 was to examine what types of goods, services and works related to the delivery of a structure over its life cycle are suitable for auction. With view to the findings of the research, it can be concluded that the use of auctions is suitable for tenders of non-unique contracts for the delivery of materials and construction works with minimum price EUR 7,400.

The objective of RQ2 was to examine whether buyers and suppliers perceive the relation between reduction of bid price and product quality differently. Research findings reveal significant differences between buyers and suppliers that contribute to negative perception of e-RA on the part of the suppliers, especially in relation to price-quality relationship perception.

As was revealed in the context of RQ3, buyers and suppliers have similar expectations about basic auction rules and conditions (such as visibility, duration of bidding rounds or usage of single-item auctions instead of itemized budgets). However, only some of them take into account certain aspects that are specific to construction contracts. These include the requirement

for a proportional decrease of the winner's itemized budget after the auction or the necessity to exclude relevant fixed costs from this proportional decrease. In this regard, exchange of knowledge between the two sides and also towards e-RA nonusers would certainly contribute to a more positive perception of e-RA among buyers and suppliers.

From a theoretical perspective, this paper adds to the literature on purchasing and supply chain management with a better understanding of e-RA outputs in construction tenders, as it has revealed an important effect of post-auction factors (Figure 1.). This issue had not yet been addressed by the research community and therefore represents another important theoretical contribution of this study. The study also gathered original data on e-RA within public sector construction procurement, which contributes to the limited knowledge on purchasing and supply management in this area.

From managerial perspective, the main contributions of this research are in the critical review of suitability of auctions with regard to the nature of the product demanded and the ability of the buyer to describe it in sufficient detail. This point is key for the success of the purchase (which is often very costly), as it forms the basis of a potential drop in quality or increased unwillingness of suppliers to submit an electronic bid. With view to the price-quality relationship in construction works, the presented results contribute to reasonable use of auctions and decrease the risks of failing to achieve project targets. The paper also stresses the relationship between the completeness and accuracy of project documentation and billing additional costs and the use of multi-criteria evaluation with regard to the expected life-cycle costs of the structure.

Another significant contribution of the paper is related to the setting of the auctions and the paper also emphasizes one post-auction factor, which is essential in the construction industry: the need for proper supervision. Research findings confirm that e-RA can be successfully used in public sector construction procurement, if used in a proper manner and with view to certain limitations.

The study has three limitations that need to be addressed. Firstly, the study is based on interviews limited to Czech buyers and suppliers. The level of IT skills may differ significantly between individual countries or there may be cultural, legislative, market or other differences that influence the decision-making regarding the adoption of e-procurement technologies, including e-RA. Therefore, the comparison of e-RA use in the construction sector in various countries represents one future area for research.

Secondly, the performed qualitative research does not examine the features of specific e-RA systems used by the respondents. It is possible that users'

perception of e-RA may be influenced to a certain extent by the quality of the system they use.

Thirdly, as e-RA in the Czech Republic are generally purchased in a technologically undemanding form (buying a license providing and remote access to the system via a web interface), this study does not address the ICT aspect in detail.

There are still many aspects of the use of e-RA in the construction sector (as well as in other sectors) which should be investigated. In particular, research into the use and perception of auctions with regard to the level of corruption could prove to be an interesting area. It may be presumed that in an environment with a relatively high level of corruption there will be more suppliers with a positive attitude to auctions due to a fair opportunity to win a contract.

Additional works also represent an area that deserves a more detailed analysis. Future research should show to what extent suppliers may in fact compensate for low bid prices by billing additional works. This problem is closely related to the fact that the final value of a construction contract cannot be determined in advance. In other words, this means that the assessment of actually achieved savings should take into account not only the expected value of the contract and the lowest bid price gained through an auction, but also the final price of the construction works.

Another interesting factor is the possibility of evaluating the satisfaction of the users of structures in connection with e-RA. However, this is a difficult challenge, as users may differ from buyers; moreover, buildings and other structures are usually used for several decades, which could create a significant time gap between the use of the structures and the auctions.

Finally, there is a significant potential for the use of auctions as a way to take the total costs of the life cycle of the structures into account, e.g. by using the expected operation costs as one of the evaluation criteria.

### Acknowledgements

*This paper has been worked out under the project No. LO1408 AdMaS UP - Advanced Materials, Structures and Technologies, supported by Ministry of Education, Youth and Sports under the National Sustainability Programme I.*

### References

- [1]. Travaglini, A., Radujkovic, M., Mancini, M. (2014). Building information modelling (BIM) and project management: a stakeholders perspective. *Organization, Technology & Management in Construction: An International Journal*, 6(2), 1058-1065.
- [2]. Peansupap, V. \* Walker, D.H.T. (2004). Strategic adoption of information and communication technology (ICT): case studies of construction contractors. *Proceedings of the 20th Annual ARCOM Conference*, vol. 2, 1235-1245.
- [3]. Olde Scholtenhuis, L.L., Dorée, A.G., Hartmann, T. (2011). Challenges for Construction IT adoption on project level, *Proceedings of the 27th Annual Conference ARCOM*, 443-452.
- [4]. KPMG (2016). Global Construction Survey, 2016.
- [5]. Petrosyan, M.O., Kovalev, I.V., Zelenkov, P.V., Chuvashova, M.N., Grishina, I.A., Pershakova, K.K. (2016). On the question of economic efficiency and how to assess it. *IOP Conference Series: Materials Science and Engineering*, 122(1), 5 p.
- [6]. Soukopová, J. & Struk, M. (2011). Methodology for the efficiency evaluation of the municipal environmental protection expenditure. *IFIP Advances in Information and Communication Technology*, 359, 327-340.
- [7]. Schoenherr, T., Modi, S.B., Benton, W.C., Carter, C.R., Choi, T.Y., Larson, P.D. et al. (2012). Research opportunities in purchasing and supply management. *International Journal of Production Research*, 50(16), 4556-4579.
- [8]. Zheng, J., Roehrich, J.K., Lewis, M.A. (2008). The dynamics of contractual and relational governance: Evidence from long-term public-private procurement arrangements. *Journal of Purchasing and Supply Management*, 14(1), 43-54.
- [9]. Carter, C.R., Kaufmann, L., Beall, S., Carter, P.L., Hendrick, T.E., Petersen, K.J. (2004). Reverse auctions - grounded theory from the buyer and supplier perspective, *Transportation Research Part E: Logistics and Transportation Review*, 40(3), 229-254.
- [10]. Wamurizi, S. (2009). Using electronic reverse auctions in project procurement: perceptions of construction contractors. *Proceedings of the 25th Annual ARCOM Conference*, 167-176.
- [11]. Ballesteros-Pérez, P. & Skitmore, M. (2016). On the distribution of bids for construction contract auctions. *Construction Management and Economics*, 35(3).
- [12]. Zunk, B.M., Marchner, M.J., Uitz, I., Lerch, C., Schiele, H. (2014). The Role of e-Procurement in the Austrian Construction Industry: Adoption Rate, Benefits and Barriers. *International Journal of Industrial Engineering and Management*, 5(1), 13-21.

- [13]. Oziveni, o.s. (2013). Používání e-aukcí při zadávání veřejných zakázek v ČR: evidence a analýza dat za roky 2007–2012.
- [14]. European Commission (2011). Evaluation Report – Impact and Effectiveness of EU Public Procurement Legislation Part 1.
- [15]. Cabral, O., Ferreira, L., Dias, G.P. (2016). Adoption of reverse auctions in public e-procurement: the case of Portugal. *11th Iberian Conference on Information Systems and Technologies (CISTI)*, 5 p.
- [16]. Hawkins, T., Randall, W., Wittmann, M. (2009). An Empirical Examination of Reverse Auction Appropriateness in B2B Source Selection. *Journal of Supply Chain Management*, 45(4), 55-71.
- [17]. Kumar, S. & Maher, M. (2008). Are the temptations of online reverse auctions appropriate for your business?. *Supply Chain Management: An International Journal*, 13(4), 304-316.
- [18]. Mabert, V.A. & Skeels, J.A. (2002). Internet reverse auctions: Valuable tool in experienced hands. *Business Horizons*, 45(4), 70-6.
- [19]. Kaufmann, R.J. & Carter, C.R. (2004). Deciding on the mode of negotiation: to auction or not to auction electronically. *Journal of Supply Chain Management*, 40(2), 15-26.
- [20]. Hawkins, T., Coyne, A., Hudgens, B. (2010). Exploring the Application of Electronic Reverse Auctions in Federal Procurement: Removing Barriers to Unleash Savings. *Air Force Journal of Logistics*, 34(1), 2-15.
- [21]. Standing, S., Standing, C., Love, P., Gengatharen, D. (2013). How organizing visions influence the adoption and use of reverse auctions. *Electronic Commerce Research*, 13(4), 493-511.
- [22]. Wamuziri, S. & Abu-Shaabani, N. (2005). Potential of reverse auctions in construction procurement. *Proceedings 21st Annual ARCOM Conference*, vol. 1, 611–619.
- [23]. Tkáč, M., Delina, R., Sabolová, M. (2016). Analysis of request for proposals in construction industry. *Quality Innovation Prosperity*, 20(1), 104-117.
- [24]. Chaturvedi, A. (2015). Procurement auctions with capacity constrained suppliers. *European Journal of Operational Research*, 247(3), 987-995.
- [25]. Jap, S. (2003). An exploratory study of the introduction of online reverse auctions. *Journal of Marketing*, 67(3), 96-107.
- [26]. Brook, M. (2008). Estimating and Tendering for Construction Work, third edition, Elsevier Butterworth-Heinemann.
- [27]. Lösch, A. & Lambert, J.S. (2007). E-Reverse Auctions Revisited: An Analysis of Context, Buyer-Supplier Relations and Information Behavior. *The Journal of Supply Chain Management*, 43(4), 47-63.
- [28]. Gabbard, E.G. (2003). Electronic Reverse Auctions — The Good and the Bad. *ISM's 88th Annual International Supply Management Conference Proceedings*, 4 p.
- [29]. Sičáková-Beblavá, E., Šatníková, S., Klátik, P. (2011). Electronic auctions in public procurement: Theory and Practice in the Slovak Republic. *Transparency International Slovensko*, 68 p.
- [30]. Gugler, K., Weichselbaumer, M., Zulehner, C. (2015). Competition in the economic crisis: Analysis of procurement auctions. *European Economic Review*, 73, 35-57.
- [31]. Ballesteros-Pérez, P., Skitmore, M. (2016). Estimating the number of new and repeated bidders in construction auctions. *Construction Management and Economics*, 34(12), 919-934.
- [32]. Hanák, T. (2016). Electronic reverse auctions in public construction procurement - empirical evidence from the Czech Republic. *Archives of Civil Engineering*, 62(3), 47-60.
- [33]. Hawkins, T.G., Randall, W.S., Coyne, A.V., Baitalmal, M.H. (2014). Sustainable integrity: how reverse auctions can benefit suppliers in emerging markets. *Supply Chain Management: An International Journal*, 19(2), 126-141.
- [34]. Standaert, W., Muylle, S., Amelinckx, I. (2015). An Empirical Study of Electronic Reverse Auction Project Outcomes. *Electronic Commerce Research and Applications*, 14, 81-94.
- [35]. Bermudez, G.M.T., G-Bustelo, B.C.P., Martiinez, O.S., Alvarez, B.T., Rojas, L.A.R. (2014). Reverse electronic auction web tool for B2B. *Computers in Industry*, 65(5), 841-849.
- [36]. Huang, M., Qian, X., Fang, S., Wang, X. (2016). Winner determination for risk aversion buyers in multi-attribute reverse auction. *Omega (United Kingdom)*, 59, 184-200.
- [37]. Love, P.E.D. & Li, H. (2000). Quantifying the causes and costs of rework in construction. *Construction Management and Economics*, 18(4), 479-490.
- [38]. Rosenfeld, Y. (2009). Cost of quality versus cost of non-quality in construction: the crucial balance. *Construction Management and Economics*, 27(2), 107-117.
- [39]. Lin, C. & Kong, D. (2015). The study of the relationship between bidding price and quality of public construction project in Taiwan. *Journal of the Chinese Institute of Civil and Hydraulic Engineering*, 27(2), 113-123.
- [40]. Setia, P. & Speier-Pero, C. (2015). Reverse auctions to innovate procurement processes: Effects of bid information presentation design on a supplier's bidding outcome. *Decision Sciences*, 46(2), 333-366.
- [41]. Caniëls, M.C.J. & van Raaij, E.M. (2009). Do all suppliers dislike electronic reverse auctions?. *Journal of Purchasing and Supply Management*, 15(1), 12–23.
- [42]. Ray, A.K., Jenamani, M., Mohapatra, P.K.J. (2011). An efficient reverse auction mechanism for limited supplier base. *Electronic Commerce Research and Applications*, 10(2), 170-182.
- [43]. Jap, S. (2007). The impact of online reverse auction design on buyer-supplier relationships. *Journal of Marketing*, 71(1), 146-159.
- [44]. Tunca, T., Wu, D., Zhong, F. (2013). An empirical analysis of price, quality, and incumbency in service procurement auctions. Working paper, 33 p.
- [45]. Conti, P.L., De Giovanni, L., Naldi, M. (2012). A rank-and-compare algorithm to detect abnormally low bids in procurement auctions. *Electronic Commerce Research and Applications*, 11(2), 192-203.

- [46]. Charki, M.H. & Josserand, E. (2008). Online reverse auctions and the dynamics of trust. *Journal of Management Information Systems*, 24(4), 175-197.
- [47]. Brisset, K., Cochard, F., Le Gallo, J. (2015), Secret versus public reserve price in an "outcry" English procurement auction: Experimental results, *International Journal of Production Economics*, 169, 285-298.
- [48]. Yenyurt, S. Watson, S., Carter, C.R., Stevens, C.K. (2011). To bid or not to bid: Drivers of bidding behavior in electronic reverse auctions. *Journal of Supply Chain Management*, 47(1), 60-72.
- [49]. Korytářová, J., Hanák, T., Hrabincová, D., Hromádka, V., Marková, L., Puchýř, B. (2011). Methodical recommendations for unification of qualification and evaluation criteria for public works contracts, 77 p.
- [50]. Edler, J. & Georghiou, L. (2007). Public procurement and innovation-resurrecting the demand side, *Research Policy*, 36(7), 949-963.
- [51]. Bergman, M.A. & Lundberg, S. (2013). Tender evaluation and supplier selection methods in public procurement. *Journal of Purchasing and Supply Management*, 19(2), 73-83.
- [52]. Ancarani, A. (2009). Supplier evaluation in local public services: Application of a model of value for customer. *Journal of Purchasing and Supply Management*, 15(1), 33-42.
- [53]. Costantino, N., Dotoli, M., Falagario, M., Sciancalepore, F. (2012). Balancing the additional costs of purchasing and the vendor set dimension to reduce public procurement costs. *Journal of Purchasing and Supply Management*, 18(3), 189-198.
- [54]. Loader, K. (2015). SME suppliers and the challenge of public procurement: Evidence revealed by a UK government online feedback facility. *Journal of Purchasing and Supply Management*, 21(2), 103-112.
- [55]. Act no. 134/2016 Coll. On Public contracts, Official Gazette, Czech Republic.
- [56]. Dubois, A. & Gadde, L. (2000). Supply strategy and network effects - purchasing behaviour in the construction industry. *European Journal of Purchasing and Supply Management*, 6(3-4), 207-215.
- [57]. Ceric, A. (2014). Minimizing communication risk in construction: A Delphi study of the key role of project managers. *Journal of Civil Engineering and Management*, 20(6), 829-838.
- [58]. Sovacool, B. K., Gilbert, A., & Nugent, D. (2014). An international comparative assessment of construction cost overruns for electricity infrastructure. *Energy Research & Social Science*, 3, 152-160.
- [59]. Love, P.E.D., Ahiaga-Dagbui, D.D., Irani, Z. (2016). Cost overruns in transportation infrastructure projects: Sowing the seeds for a probabilistic theory of causation. *Transportation Research Part A: Policy and Practice*, 92, 184-194.
- [60]. Soliño, A.S. (2014). Analysis of the optimal sharing of construction risk in public procurement contracts. *Revista De La Construcción*, 13(1), 74-80.
- [61]. El-Sawalhi, N., Eaton, D., Rustom, R. (2007). Contractor pre-qualification model: State-of-the-art. *International Journal of Project Management*, 25(5), 465-474.
- [62]. Lam, K.C., Palaneeswaran, E., Yu, C. (2009). A support vector machine model for contractor prequalification. *Automation in Construction*, 18(3), 321-329.
- [63]. Manoliadis, O.G., Pantouvakis, J.P., Christodoulou, S. (2009). Improving qualifications-based selection by use of the fuzzy Delphi method. *Construction Management and Economics*, 27(4), 373-384.
- [64]. Porwal, A. & Hewage, K.N. (2013). Building Information Modeling (BIM) partnering framework for public construction projects, *Automation in Construction*, 31, 204-214.
- [65]. Žujo, V., Žileska-Pančovska, V., Petruševa, S., Petrovski, A. (2017). Construction managers' perception for sustainable construction contributing factors: Analysis using support vector machine. *TEM Journal*, 6(2), 391-399.
- [66]. Hanák, T., Muchová, P. (2015). Impact of competition on prices in public sector procurement. *Procedia Computer Science*, 64, 729-735.
- [67]. Četković, J., Knežević, M., Žarković, M., Murgul, V., Vatin, N. (2014). Development and competitiveness improvement of the construction sector in Montenegro, *Applied Mechanics and Materials*, 638-640, 2465-2470.
- [68]. Act. No. 25/2006 Coll. on public procurement, effective on 1.1.2012 Official Gazette, Slovakia.
- [69]. Abu-ElSamen, A., Chakraborty, G., Warren, D.A. (2010). A process-based analysis of e-procurement adoption. *Journal of Internet Commerce*, 9(3-4), 243-259.