# PROZORRO E-AUCTIONS: SAVINGS ON PUBLIC PROCUREMENT OF MEDICINES IN UKRAINE

by

Oleksandra Chmel

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Thesis Supervisor: _____ Professor Maksym Obrizan

Approved by _____
Head of the KSE Defense Committee, Professor Tymofiy Mylovanov

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Date _____

Kyiv School of Economics

Abstract

# PROZORRO E-AUCTIONS: SAVINGS ON PUBLIC PROCUREMENT OF MEDICINES IN UKRAINE

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This thesis assesses the effect of the introduction of the PROZORRO electronic system in the field of public procurement of medicines in Ukraine. The electronic system started to work from 2015 in test mode simultaneously with the non-electronic system, and since August, 2016 participation in the e-auction has become obligatory for all participants and purchasers.

The period 2013-2017 is considered, thus there is a base for comparison, which covers the period up to 2015. According to the results of the OLS model, the savings from the appearance of the PROZORRO system are higher than from the non-electronic auction. At the same time, savings from using the PROZORRO system in an obligatory mode are larger than in previous periods.

Also, the analysis of 10 groups of medicines for the price lower than 35 UAH, as well as the investigation of some selected drugs (Analgin, Atropine, L-Lysine Aescinat, Dithylin, and Vicasolum) is studied separately.

To Alla Chmel

for her believing in me and trust

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# LIST OF ABBREVIATIONS

FOP –individual Entrepreneur,

KOATUU – Classifier of objects of the administrative-territorial structure of Ukraine,

LLC – Limited Liability Company,

MOH – Ministry of Health of Ukraine,

OLS – ordinary least squares,

UNDP – the United Nations Development Programme,

UNICEF – the United Nations International Children's Emergency Fund,

USREOU – Unified State Register of Enterprises and Organizations of Ukraine,

VAT – value added tax,

VIF – variance inflation factor.

*Chapter 1*

# INTRODUCTION

With the creation of the Ukrainian electronic system of public procurement, PROZORRO, there appeared to be one important question of the effectiveness evaluation of the e-auction when compared with the previous one.

The following events precede the introduction of the electronic procurement system. The first law on the public procurement known as the No.1490-14 "On procurement of goods, works, and services for public funds"[1] was adopted on February 22, 2000. The next Law No.2289-17 "On government procurement"[2] operated from June 1, 2010, to April 14, 2014. This document became the legal basis for the goods, works, and services purchased by the state organizations through the auctions during this period. However, the risk of corruption continued to reduce the effectiveness and the benefits of newly created auction mechanism which allows decreasing the cost of procurement. To overcome this problem and to introduce the transparent and fair procurement procedures, the further steps have been taken by the Government of Ukraine. The new Law of Ukraine No.1197-18 "On Public Procurement"[3] was adopted on April 10, 2014, and acted in the interim period from 2014 to 2015. The current Law No.922-19 "On Public Procurement"[4] (hereinafter referred to as the Law) has been adopted on December 25, 2015, and PROZORRO platform which is the information and

[1] http://zakon3.rada.gov.ua/laws/show/1490-14

[2] http://zakon5.rada.gov.ua/laws/show/2289-17

[3] http://zakon5.rada.gov.ua/laws/show/1197-18

[4] http://zakon5.rada.gov.ua/laws/show/922-19

telecommunication system has been established. Starting from August 1, 2016, the participation in the electronic auctions becomes obligatory for all organizers and managers of public funds.

From 2008 to 2016 there was the web-portal "Bulletin of Public Procurement"[5], where the qualification documents, protocols of proposals disclosure for competitive bidding, reports on the results of the procurement procedures, as well as the price per unit of goods in accordance with the contract could be found. It should be noted that not all data is available online and it is only possible to download the data starting from the end of 2012, while the data from the other periods is sometimes missing or unavailable.

As for the new procurement electronic system, the efficiency indicator is perceived as the percentage of savings of each lot. That is the decrease in contract price in comparison with the expected value is assumed to be the auction savings. In such a case, the price means the total cost of a lot (if some tender consists of multiple lots) or a total cost of a tender (if it consists of just one lot). There are some clarifications regarding the calculation of the efficiency of the new procurement system. First, the presence of the several items in every lot is not taken into account. Second, there is no clear understanding of whether a savings indicator is a qualitative indicator or a quantitative one. Third, the use of expected value as a basis for comparison makes it impossible to contrast the economic benefits from the PROZORRO creation because the concept of "expected value" is absent in the system of public procurement till 2015.

The most common case is the following one when some hypothetical lot consists of more than one item. For example, the gas/oil, etc. is usually bought separately

[5] https://ips.vdz.ua

from each other, and that is a homogeneous product purchase. However, the other groups of work/services/goods are heterogeneous products, for example, buying various kinds of paper. One organizer, who conducts an auction to buy more than 100 different items, is not comparable with another organizer, who conducts an auction to buy one item. The reason is that the savings from the purchase of each product may significantly vary in multi-item auctions. This trend might be observed in both systems, before- and after-PROZORRO.

According to the Law, the participants of preliminary qualification submit all documents needed for the qualification criteria. Among other rules defined by the Law for accepting participants are the experience, commitment to previous similar contracts, availability of material and technical base, financial capacity. After qualification the participants take part in a dynamic auction and winner among them may be defined by the price criterion. Although, other possible rules according to the Law are "the quality of performed work and services, payment terms, execution terms, warranty service and operational expenses, technology sharing and the managerial, scientific and other personnel training, including the usage of local resources, including means of production, labor and materials for the goods manufacturing, and provision of services offered by the participant"[6].

Unfortunately, the new public procurement system did not change the approach of the government purchasers to assessing bids at the level of quality indicators such as discounts, delivery terms, additional guarantees, etc. The most used criterion for evaluating the bids during the auctions is the lowest price in comparison with the other auction participants' prices. That is the bid with the lowest price wins the auction, without taking into account its quality components.

[6] http://zakon5.rada.gov.ua/laws/show/922-19

The investigation of this paper is focused on the procurement process in the "Medical equipment, pharmaceuticals and personal care products" coded as section 33 under the new system, which follows the "Single Procurement Dictionary" ("Yedynyy zakupivel′nyy slovnyk") DK 021:2015. The same area of research is called "Pharmaceutical products and pharmaceuticals" and it is coded as section 21 in the old procurement system, but it follows the State Classifier of Products and Services DK 016-2010.

In this analysis, after taking into account the clarifications listed above, the evaluation of PROZORRO system has been made based on auction savings at the unit price level. In contrast to the used current efficiency indicator (in the PROZORRO electronic system), the purchaser's benefit is calculated as the comparison between the weighted average retail price of goods' unit in Ukrainian pharmacies with a price specified in the contract. The information about agreement price under the old system may be found in the attachments on the site "State Procurement Bulletin"[7] ("Visnyk derzhavnykh zakupivel", hereinafter referred to as Visnyk). Under the new system, the information about the agreement prices may be found in the agreement specification on the PROZORRO web site. The item prices of each lot in the procurement of the medicines (with PROZORRO references and organizers/tenderers names) have been gathered by "NASHI GROSHI"[8] and the period of these auctions' is 2016-2017.

A substantial addition to the research is the division of data for analysis into three periods: the old system (until 2015), while the PROZORRO has been working in

[7] https://ips.vdz.ua

[8] http://nashigroshi.org/2017/04/28/zakupivelni-tsiny-na-liky-v-ukrajini

test mode, that is the existence of both systems simultaneously (until August in 2016), and the mandatory usage of PROZORRO system (from August 1, 2016).

Chapter 2 describes the contribution of the scientists to the analysis of public procurement procedures. Taking into account that the current auction in Ukraine is a combination of the reverse first-price sealed-bid auction and the reverse dynamic three-round auction (where a bidder with the lowest price wins in a procurement auction), such empirical analysis has not been greatly discussed in the scientific world. Therefore, this paper will discuss possible answers to the most urgent and peculiar questions. Chapter 3 covers a part of a methodology that describes the construction of a dependent variable and the use of OLS model for several sub-samples. In Chapter 4 the data description of the set of variables is presented. Chapter 5 summarizes the empirical results and Chapter 6 – the conclusions and policy implications.

*Chapter 2*

# LITERATURE REVIEW

There are many papers which provide the comparison of the different types of auctions. But at the same time, these works do not state the methodology of solving the "Ukrainian case". Generally, the three-round auction with a public reserve price and an additional pre-level (the so-called "blind level" allows a buyer to check the seller's good's (or services', or work's) proposals for compliance with the tender documentation) has not been studied to a sufficient degree.

According to the revised literature, it is possible to distinguish between the most frequently compared types of auctions: first- and second price auction, average bid auction, a multi-round auction with secret reserve price (in contrast, in Ukraine the public reserve price is used). The multi-round auctions with secret reserve prices are being investigated by Lu Ji, Tong Li (2008), where the bidders' behavior and the organizer's expected value have been evaluated. The constructed theoretical model confirmed the decrease of the average bid from round to round. Under some specifications, the secret reserve price promoted better results for auctioneer than the public reserve price. The empirical model was based on INDOT (the Indiana Department of Transportation) data, and the counterfactual analysis was conducted. One of the article's results may serve as an example for the Ukrainian government in the future. In case of non-forward-looking tenderers, when the reserve price is kept secret, the benefit of an auction procedure is preferable for state organizations. First and foremost, this might be considered fair for the purchase of services (for example, bridge work).

The earlier investigation of Athey, J.Levin, E.Seira (2011) use the data from the U.S. Forest Service timber auctions to study the entry and bidding patterns in the sealed bid (first case) and the open auctions (second case). The smaller bidders appear to be more attractive in the first case, which generally generates higher revenue. Such findings may be explained throughout the extension of the standard independent private values auction, and they will allow measuring the degree of bidder competitiveness. The study of Decarolis et al. (2017) continues the comparison of the first price auctions. The first price auctions with the ex-post screening of bid responsiveness (first case) are compared with the average bid auctions where the bidder closest to the average bid wins (second case) using the data from the Italian procurement system. As a result, the second case appears to be less efficient for the bidders. The losses which occur under the second case indicate that the given auction fails to select the lowest bidder in 2/3 cases and the average production cost is 1/6 higher in the second case than in that first one.

In the MA thesis Kheilyk (2017) investigates the difference between the first-price and two-stage auctions. A comparison of the auctioneer's revenue with two types of auction was made and it was found that a two-stage auction is less favorable than the first-price auction. It was concluded that for the PROZORRO three-stage auction system, it was better to change the type of auction for the first-price auction, which is to return to the previous auction type in public procurement.

As for the buyer's ability to run the procurement procedure, A.Bucciol, R.Adani, P.Valbonesi (2017) investigate such cases using the auction prices of medical equipment and the costs of production of this equipment in the Italian procurement. The reference price under consideration was active starting from July 2012 to May 2013. Moreover, the whole period of the empirical analysis was 2013. Consequently, one of the results was the assessment of a significant positive effect of the reference price regime on low-ability purchases, and vice versa for the high-

ability purchases. The agreement price was also affected by the state organization size (the public hospitals conducted the purchases at less prices than local organizations) and the geographical location.

However, in Ukraine, neither during the period of the old system nor the period of the new one, the reference price, as the price for one unit, is not a correct stated price. According to the Resolution No.240[9] of the Cabinet of Ministers of Ukraine (the valid document was approved in July 2014) and the Order "On Approval of the Regulation on the Register of Wholesale Prices for Medicines and Products for Medical Purposes, the Procedure for Making Changes and Form of the Declaration of Change in the Wholesale and Retail Price for a Medicinal Product and the Product for Medical Purposes" No.574[10] of the Ministry of Health of Ukraine (the valid document was approved in August 2014), the form of release, dosage and packaging shall be declared at the price change for the corresponding medicinal product. The document, which contains the list of all medicines and the corresponding wholesale-selling prices, is called "Register of wholesale and retail prices for medicines". However, since every year many changes are added to this Register, it shall not be used during this research.

Another part of the work covers the use of e-auction in public procurement, which ensures transparency and leads to increased competition, which in turn increases the amount of savings for state-owned enterprises. Carayannis et al (2005) made an analysis of the central and eastern European countries e-procurement. The contribution of this work is as follows: the creation of an electronic system on the one hand leads to transparency and efficiency in public procurement, and on the other hand it brings with it additional costs such as the need for the seller, as well

[9] http://zakon2.rada.gov.ua/laws/show/240-2014-п

[10] http://zakon2.rada.gov.ua/laws/show/z1097-14

as the buyer, computer and Internet access, level of abilities of working personnel for use and maintenance of the electronic system, etc. The other investigation of Rasto et al (2017) shows the influence of using the e-procurement in public hospitals. The positive effects of the introduction of the e-auction have been increased competition through the availability of information and participation in the tender for participants, the use of e-invoicing as well as electronic auction leads to an increase in the effectiveness of the auction, while e-payment can affect the reduction of transaction costs and do payments are more secure.

In this paper, only the effect of the use of e-auction is being studied, as stated in analytical work, to a greater extent this leads to a positive effect of the efficiency growth, and therefore of savings, but at the same time, this effect can be reduced by changing the type of auction by the Ukrainian the government.

*Chapter 3*

# METHODOLOGY

As noted in Chapter 1, this analysis estimates the change in the auction savings as the effectiveness of the e-auction in comparison with the previously existing procurement auction in Ukraine.

The considered indicator of the auction efficiency reflects the comparison between the weighted average retail price of goods' units in Ukrainian pharmacies and the contract price. It is calculated as:

$$Savings = \frac{Retail - Contract}{Retail} * 100\% \quad (1)$$

where *Retail* – the retail price,

*Contract* – the contract price.

The higher is the percentage increase in Savings, the more effective the auction appears to be. The variables "Savings" was created by the author herself, since no previous works introduce any similar variable for the indication of auction efficiency.

According to the Tax Code of Ukraine[11], the supply and import of medicines to Ukraine during the analyzed period had different tax rates (20% – before April 19,

[11] http://zakon3.rada.gov.ua/laws/show/2755-17

2014, and 7% – after). Therefore, the contract price is reduced to a single base as a price without VAT.

The following hypotheses are made:

1. The implementation of the PROZORRO system positively influenced the increase in the efficiency of public procurement auctions (starting from the test mode of PROZORRO system).

2. The abolishment of the old system and the mandatory transition to the PROZORRO system demonstrated higher savings rates from the use of auctions.

In order to answer the research question, the OLS and logit models have been constructed. The models cover the periods from 2013 to 2017. Moreover, the dataset for analysis is divided into three groups:

1. 2013 – 2015 – the "before-PROZORRO" system.

2. January 2016 – July 2016 – test mode of PROZORRO system.

3. August 2016 – 2017 – mandatory use of PROZORRO by all participants.

Therefore, the categorical variable "Time", which controls for the various time intervals mentioned above and indicates the impact of introducing the PROZORRO system in public procurement (during the separate test and the mandatory system usage), is created.

The binary variable to indicate the auction type is named "eAuction", and it is used to show whether the new or old system is applied. So the savings of usage of PROZORRO will be compared with the old system's savings. The two groups are

presented according to Visnyk and Prozorro data. The first one is the organizers and bidders who did not use e-auction (the value of the variable is equal to zero), and the other one is those organizers and bidders who used PROZORRO (the value of the variable is equal to one). This was done to differentiate the auctions during PROZORRO's operation in test mode when not all participants and organizers switched to the test-mode of PROZORRO system.

The relationship between price savings and the number of bidders is assumed to be nonlinear (concave downward sloping). In his MA thesis, Nedilchenko[12] (2017) assumes the positive impact of the number of bidders on the level of savings in procurement. Therefore, the dependent variable is considered to have a hyperbolic relationship with the independent variable, which is the number of bidders.

In the further estimated model, at first the efficiency indicator increases but at a decreasing rate, that is the number of bidders rises, but after some number, efficiency indicator begins to go up at the decreasing rate. That is why the quadratic variable "number of bidders" is added to the model.

Similarly, a new variable is constructed from the "number of items per tender" - the logarithm of items – which is assumed that after such transformation the number of items will be normally distributed. The reason for this may be the fact that with a large number of items in the tender, checking the proposals of participants requires more time and attention.

In "before-PROZORRO period", the common situation is when the winner of the auction and the purchaser are from one region (the region is defined as oblast; therefore there are 24 oblasts (further, regions) and Kyiv, Sevastopil cities). It can be explained, for example, by the transaction costs such as additional

[12] http://www.kse.org.ua/download.php?downloadid=873

transportation costs to get to the venue of the auction. Since it may introduce a less competitive environment between the bidders, the dummy variable "Region" is added to the model, and it points to whether or not the winner and the organizer are from different regions (the variable is equal to one if the region of the participant and the winner is the same). It should be noted that the control over all bidders is not conducted in this research. The information about winners, in particular, their region does explain that the availability of PROZORRO system leads to the reducing of the above-indicated transaction costs. These variable explains the effect of the geographical location on the savings. Besides, the variables organizer's and bidder's region as well as "KOATUU" are also added to the model (the variable "Region" describes region and the variable "KOATUU" describes cities and villages of the participants and organizers). These variables explain the effect of the geographical location on the savings.

The suggested estimation model using OLS looks as follows:

$$\begin{aligned} Savings = {} & \beta_0 + \beta_1 * Bidder + \beta_2 * Bidder^2 + \beta_3 * \ln(Item) \\ & + \beta_4 * Disqualification + \beta_5 * eAuction + \beta_6 \\ & * Threshold + \beta_7 * Region + \beta_8 * KOATUUwin \\ & + \beta_9 * KOATUUorg + \beta_{10} * RegionWin + \beta_{11} \\ & * RegionOrg + \beta_{12} * ExperOrg + \beta_{13} \\ & * ExperWin + \beta_{14} * Entrepreneur + \beta_{15} \\ & * ln(Quantity) + \beta_{16} * ln(Share) + \beta_{17} * Time \\ & + \beta_{18} * Month + \varepsilon \end{aligned} \quad (2)$$

where *Bidder* – number of bidders in a lot,

*Item* – number of items in a tender,

*Disqualification* (binary variable) – variable, which demonstrates whether there are some disqualifications during the auction,

*eAuction* (binary variable) – variable equals to one if the auction is conducted using the PROZORRO system, zero otherwise,

*Threshold* (binary variable) – variable, which demonstrates whether a contract price is below or above 200,000 UAH in the auction (Threshold=1 if contract price is higher than 200,000 UAH),

*Region* (binary variable) – involvement of participants from other regions; if the region of the auction winner differs from the buyer's region then Region = 1, and zero otherwise,

*ExperOrg* – number of the organizer's participations in the previous tenders,

*ExperWin* – number of the winner's participations in the previous tenders,

*Entrepreneur* (binary variable) –Entrepreneur =0 if the winner is a legal organization, Entrepreneur =1 if the winner is an entrepreneur (FOP),

*Quantity* – medicines volume,

*Share* – share of the drug price in contract price,

*KOATUUwin* – winner's KOATUU,

*KOATUUorg* – organizer's KOATUU,

*RegionWin* – winner's region (oblast),

*RegionOrg* – organizer's region (oblast),

*Time* (categorical variable) – variable explains the auction time period; Time=1 for the period 2013-2015, Time=2 for the period January 2016 – July 2016, Time=3 for the period August 2016-2017,

*Month* – month of publishing of announcement of the auction beginning.

Consequently, the key variables are eAuction and Time. The positive significant coefficients of these variables will describe the expected relationship between savings and the introduction of PROZORRO system as well as the mandatory use of the electronic auction.

The old system is limited in its information about the auctions indicators. For example, there is no data on signing / not signing an additional agreement with a particular participant before 2015. Consequently, the result of the research may not reflect the certain aspects of the procurement procedure. However, it is an opportunity to evaluate the effectiveness of the usage of the auctions through the PROZORRO system.

In order to sum up the impact of all independent variables on the auction savings, the following Table 1 presents the expected signs of the coefficients of each of the explanatory variables.

Table 1. The expected signs of explanatory variables

| Variable | Sign | Variable | Sign |
|---|---|---|---|
| eAuction | + | Bidder | + |
| Time | + | Item | – |
| Organizer's experience | + | Disqualification | – |
| Winner's experience | + | Threshold | – |
| Entrepreneur | + | Quantity | + |
| Region | – | Share | + |
| Month | + | | |

*Chapter 4*

# DATA DESCRIPTION

For the research, information about 2,193 tenders for the period 2013-2017 was collected according to the procurement procedure – competitive tenders, namely open and below threshold tenders. The number of observations in the analyzed dataset is 56,612.

There are 604 tenders of PROZORRO system data, and 1,569 tenders of old system data. Data on tenders from the old system were collected from the Visnyk web site. Moreover, the inputs on the procurement period, name, location, and USREOU of the organizer (ID code) and the winner of the auction, the amount of the contract are taken directly from the auction page. In the attached documents for the auction, there are prices per unit of the goods in the Excel and Word files, as well as in the Report on the results of the procurement procedure – the number of bidders. The PROZORRO dataset has been gathered by "NASHI GROSHI". The main contribution of this dataset is the over-rendering of PDF files into Excel files with prices for each item per lot with the names of organizers and winners. Additional information about the date of publication of tender documentation, the number of participants, region, location, and USREOU as organizers and participants, the presence of disqualification of tenderers, and the indication of inclusion / non-inclusion of the VAT to the contract amount was collected with the help of the PROZORRO BI service[13].

[13] http://bipro.prozorro.org.ua

Another dataset with weighted average retail prices was provided by the Morion, LLC on a monthly basis. It should be noted that not all the month's prices were presented in the dataset. In order to smooth these passes, prices for the next month were inserted instead of the missed prices. Given the fact that fluctuations in prices between months are not significant when compared to annual volatility, it was assumed that this replacement should not significantly affect the results of the research. Among the 15,961 different names of drugs with their pharmaceutical forms sold in Ukrainian pharmacies, 2,508 items were selected that were purchased by the government procuring units. The retail prices dataset is confidential, restricted, and available on request.

Figure 1 below and Figure A1 in Appendix A show the positive interdependence between retail prices and auction prices in order to understand how the dependent variable, namely savings, is constructed. That is, it can be said that high-cost drugs have a lower level of savings.

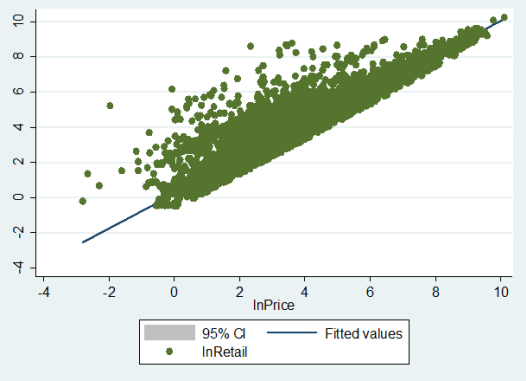


Figure 1. The relationship between retail and auction prices

One more point is to see in Table 2 below the descriptive statistics of 2 variables from which the variable Savings is constructed. The values of mean, median, min, and max of the auction prices are less than same values of the retail prices. The

average retail price is higher than the auction price not less than 15 UAH from year to year.

Table 2. Summary statistics of retail and auction prices

| Retail price | | | | | |
|---|---|---|---|---|---|
| | Mean | Median | Min | Max | Count |
| 2013 | 121.04 | 29.39 | 1.00 | 13,597.80 | 22,031 |
| 2014 | 158.87 | 38.07 | 1.00 | 27,821.00 | 14,911 |
| 2015 | 260.36 | 52.36 | 2.00 | 14,711.75 | 8,062 |
| 2016 | 222.2 | 56.02 | 2.00 | 14,719.00 | 8,809 |
| 2017 | 129.82 | 44.73 | 2.00 | 5,075.70 | 2,808 |
| Total | 167.01 | 39.10 | 1.00 | 27,821.00 | 56,621 |
| Auction price | | | | | |
| | Mean | Median | Min | Max | Count |
| 2013 | 105.14 | 27.1 | 1.00 | 12,164.85 | 22,031 |
| 2014 | 136.58 | 32.79 | 1.00 | 24,467.00 | 14,911 |
| 2015 | 219.53 | 41.8 | 1.00 | 14,445.00 | 8,062 |
| 2016 | 177.69 | 46.26 | 1.00 | 12,594.00 | 8,809 |
| 2017 | 107.98 | 36.7 | 1.00 | 4,167.60 | 2,808 |
| Total | 141.14 | 33.78 | 1.00 | 24,467.00 | 56,621 |

In accordance with the division of data into three periods, the distribution of completed purchases for the period up to 2015 includes 1,499 trades, the interim period for both systems consists of 85 trades, and the period of obligatory use of the system PROZORRO – 609 trades. Figure 2 below shows the number of the unique participants according to three periods in the context of using / not using e-auction for each oblast. The variable eAuction shows this separation. Kyiv city and Lugansk oblast had the highest number of unique participants in before-PROZORRO period. However, after the introduction of the e-auction, these values were significantly reduced, but Kyiv city retained the leading position with 17 unique bidders. The same structure of unique organizers is presented in Figure 3. For the organizers the leader is also Kyiv city and Dnipro region with the highest

number of unique purchasers which is more than 60 ones in after-PROZORRO period.

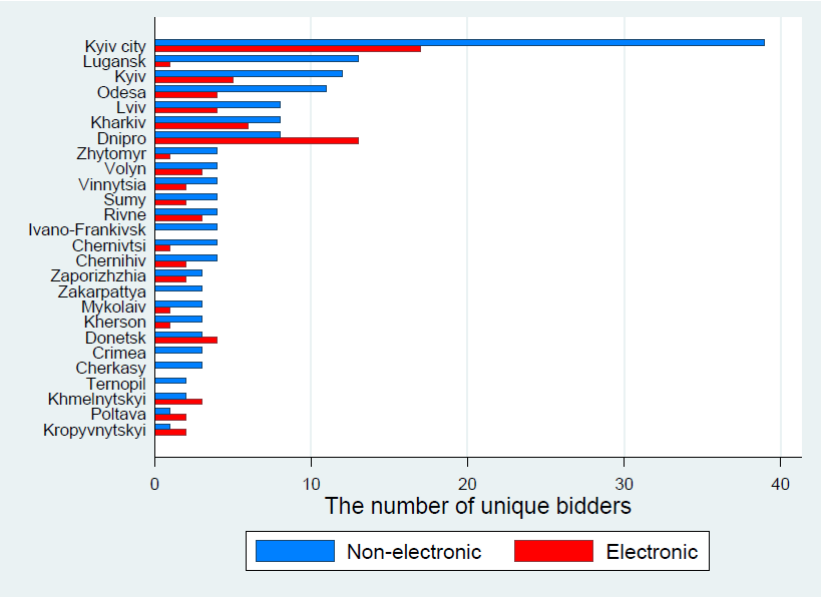


Figure 2. The distribution of the unique participants in before- and after-PROZORRO periods

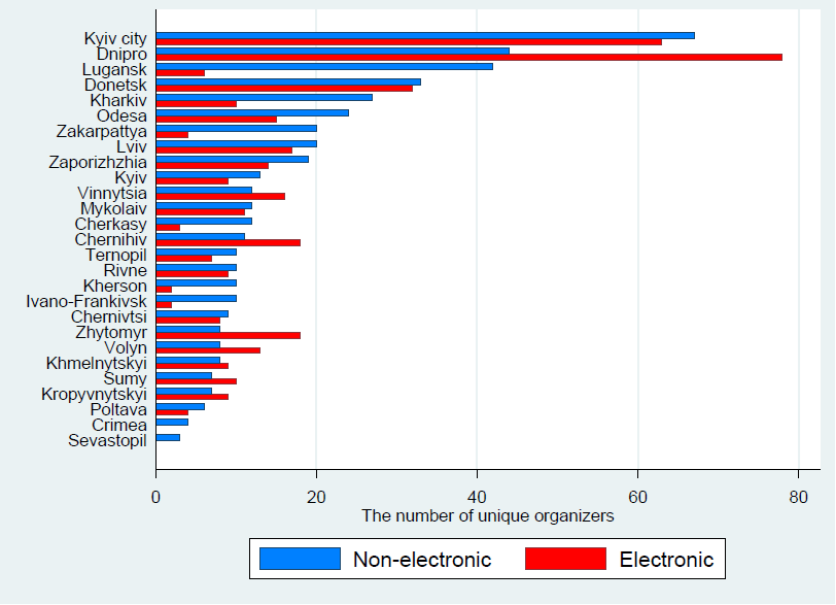


Figure 3. The distribution of the unique organizers in before- and after-PROZORRO periods

It should be added that it is possible to identify among the groups of the participants those who have the largest share of sales of medical products (an average of UAH 7,731,165 per year – 4.5% of all purchases during the year) and those who enter the market 1-3 times each year (on average UAH 7,387 per year – less than 1% of all purchases during the year). The total amount of public procurement and procurement by so-called outlays is given in Table 3 below.

Table 3. Distribution of government purchases by groups of the participants

| ContrAver | ContrGroup | | | | |
|---|---|---|---|---|---|
| | 1.Small | 2.Below median | 3.Above median | 4.Large | Total |
| | % | % | % | % | % |
| 1.Small | 73.1 | 16.7 | 0 | 0 | 5 |
| 2.Below median | 26.9 | 63.2 | 48.2 | 0 | 45 |
| 3.Above median | 0 | 20 | 49 | 75.6 | 45 |
| 4.Large | 0 | 0 | 2.9 | 24.4 | 5 |
| Total | 100 | 100 | 100 | 100 | 100 |

The variable indicating the organizational and legal form called Entrepreneur and it indicates those participants who are the FOP. Since FOPs do not need to pay the VAT, then the Savings should rise when the bidder is an Entrepreneur. The share of FOPs in the dataset is not significant and less than 5%.

The dependent variable, as the level of savings per unit, was calculated using the unit price from contracts for the public procurement of medicines and weighted average retail prices. Over time, the level of savings demonstrates a positive trend. The purpose of this analysis is to assess how the usage of the e-auction affects the change in the level of savings. Accordingly, the relationship between these two variables is illustrated in Figure 4 below. In Figure 4, there is a linear relationship between the level of savings and the binary variable indicating the use of the electronic auction. With the use of PROZORRO, the so-called auction efficiency

is increasing. To confirm this fact, the other control variables are introduced into the regression.

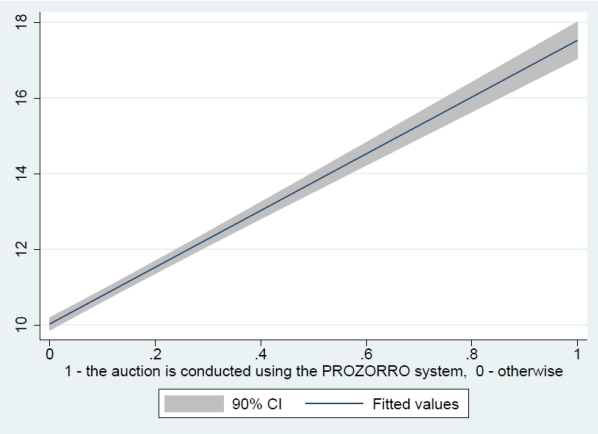


Figure 4. The relationship between the savings and the usage of PROZORRO

The descriptive statistics of independent variables are presented in Table 4 below.

Table 4. Descriptive statistics of control variables

| Means | | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | ExperWin | ExperOrg | Bidder | lnContract | lnQuantity | lnItem | lnShare |
| 2013 | 4.14 | 1.38 | 2.77 | 13.27 | 3.2 | 5.7 | -2.08 |
| 2014 | 4.24 | 1.64 | 2.58 | 13.34 | 3.16 | 5.85 | -2 |
| 2015 | 4.3 | 1.81 | 3.05 | 13.28 | 4.21 | 4.83 | -0.55 |
| 2016 | 4.33 | 1.63 | 3.19 | 12.48 | 3.84 | 4.37 | -0.09 |
| 2017 | 3.71 | 0.57 | 2.41 | 11.69 | 3.02 | 4.25 | -0.36 |
| Total | 4.14 | 1.38 | 2.77 | 13.27 | 3.2 | 5.7 | -2.08 |
| Standard deviations | | | | | | | |
| Year | Exper Win | Exper Org | Bidder | ln Contract | ln Quantity | ln Item | ln Share |
| 2013 | 1.52 | 0.96 | 2.47 | 1.31 | 1.94 | 1.09 | 2.35 |
| 2014 | 1.44 | 0.76 | 1.46 | 1.45 | 2.04 | 1.33 | 2.55 |
| 2015 | 1.41 | 0.82 | 1.67 | 1.57 | 1.91 | 1.05 | 2.47 |
| 2016 | 1.33 | 0.92 | 1.64 | 1.86 | 1.85 | 1.07 | 2.19 |
| 2017 | 1.74 | 0.67 | 0.69 | 1.76 | 1.71 | 1.07 | 2.04 |
| Total | 1.52 | 0.96 | 2.47 | 1.31 | 1.94 | 1.09 | 2.35 |

The organizers on average are less experienced than purchasers. The mean of organizers' participations in the auctions is four times per year, while the bidders' participations is approximately two times per year. On the public procurement market, there is a small number of sellers specializing in the sale of medical products because of the difficulties of entering the market. In the same time, there is a lot of hospitals, clinics, primary health care centers which could buy the drugs through the auctions.

The set of control variables which have a positive effect on the dependent variable is as follows: number of Bidders and Items in a tender, Region, Entrepreneur, Experience of the organizer and the bidder, Quantity, and Share. Unlike, it is assumed that Disqualification and Threshold variables have the negative effect on the savings. The geographical location variables such as the winner and organizer oblast, city/village determine the region with the highest level of savings. It is considered that the last quarter of the year consists of the higher number of government purchases (as it is necessary to "close" planned for the year purchases) and therefore, the greater level of saving rate. The coefficient of the variable Month explains this relationship. It is also the categorical variable Time which shows the same effect as the e-Auction variable. To see the interdependence responses, Table 5 demonstrates the correlations of these variables.

Table 5. The correlations between Savings and the control variables in a period of mandatory usage of PROZORRO

| | Savings | Bidder | Item | Region | Entrepr-r | exper Win | exper Org | Dis q-n |
|---|---|---|---|---|---|---|---|---|
| Savings | 1 | | | | | | | |
| Bidder | .082 | 1 | | | | | | |
| Item | -.039 | -.065 | 1 | | | | | |
| Region | .043 | -.001 | -.069 | 1 | | | | |
| Entrepr-r | -.008 | -.064 | .035 | **-.113** | 1 | | | |
| experWin | .065 | **-.155** | -.003 | **.247** | **-.107** | 1 | | |
| experOrg | .042 | **.130** | -.033 | .063 | -.064 | .031 | 1 | |
| Disq-n | -.057 | **.351** | .026 | **-.248** | -.057 | **-.373** | -.039 | 1 |

Note: bold are those correlations which >10%

Figure A6 in Appendix A shows the scatterplot matrices which shows the same as the correlation table results graphically.

The research of the completed competitive bidding assumes that the number of auction winners in the sample should have a normal distribution. In contrast, 80% of purchases has only two participants. However, the growth of participants during the analyzed period, presented in Figure 5 below, indicates a positive tendency for a competitive environment to grow during procurement for five years in Kharkiv, Khmelnytskyi, L'viv, Ternopil, and Zhytomyr oblasts. That, in turn, introduces the possibility of reducing the unit price and the total cost of the tender to the purchaser.

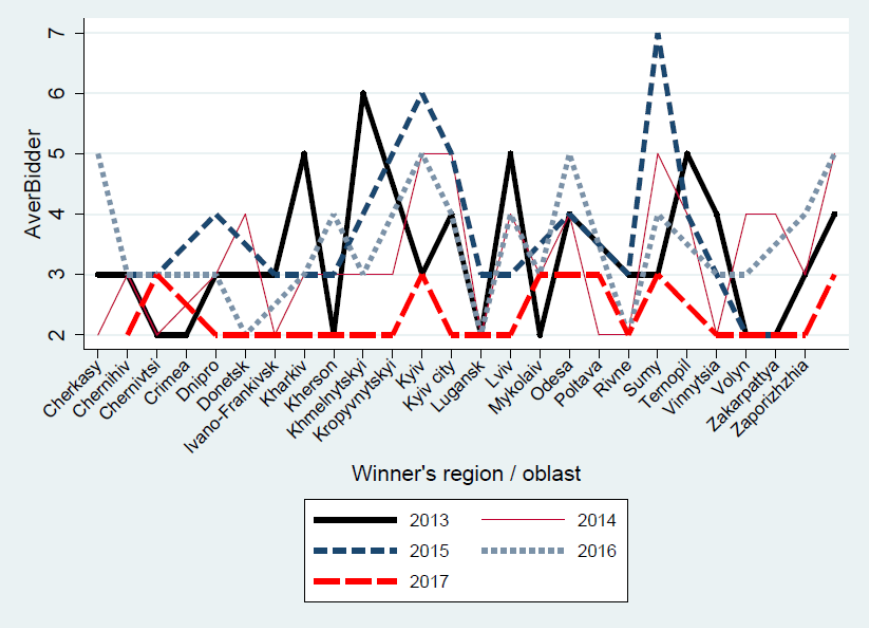


Figure 5. The average number of bidders in 2013-2017

By 2015, the organizer and participant were often from one area. While the introduction of PROZORRO allowed changing this trend and attracting more participants in the auction from locations different from the organizer's location. It is assumed that this fact leads to increased competition during the bidding and,

as a consequence, a rise in savings. Figure 6 provides a distribution map for the Region variable in 2013, and Figure 7 presents the distribution map for. Both figures clearly confirm the above-stated fact. 2017. There are 23 oblasts which have the bidders and purchasers from the same region in 2017, while there are 26 such oblasts in 2013. The problem areas are the Lviv region in 2014, Odesa region in 2015, Odessa and Dnipro region in 2016, and Dnipro in 2017. Since the number of tenders in these areas is more than 10% per year, the share of participants from other regions is low in purchases, and according to the research hypothesis, the effect of this should be negative, then attention should be paid to public procurement in these regions.

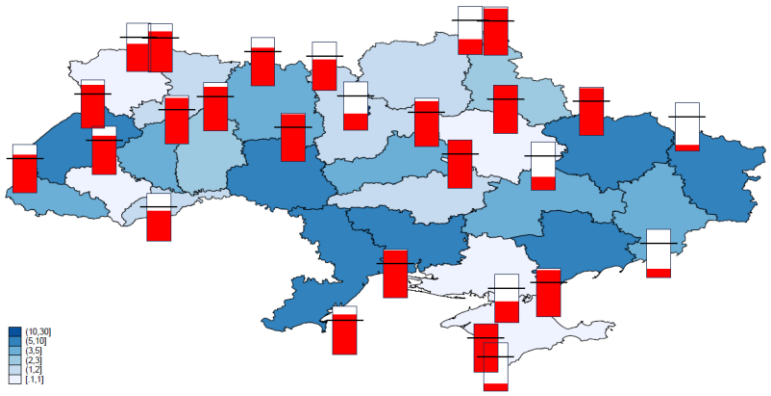

Figure 6. The total number of tenders and the distribution of Region variable bars in 2013

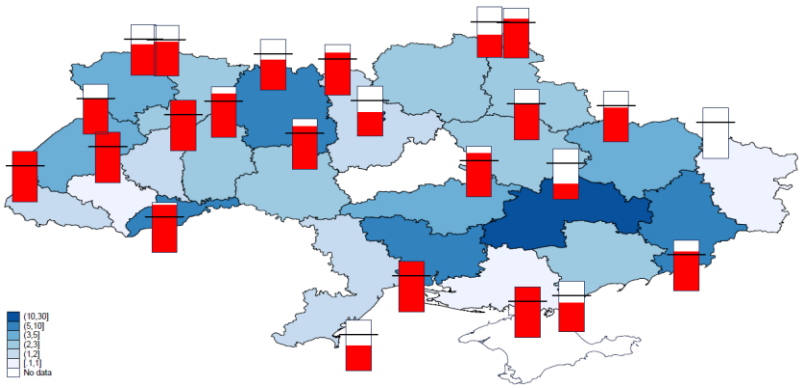

Figure 7. The total number of tenders and the distribution of Region variable bars in 2017

Part of the lots in the data sheet with the disqualification of participants concerning three periods according to the values of the variable Time is different during 2013-2017. The disqualification of one or more participants in the lot may indicate a rejection of more economically advantageous offer at the lowest price. From 2013 through 2015, the share of such disqualifications in tenders is 42.13%, and it almost changes over time. Thus, during the period of mandatory maintenance of PROZORRO, the level of disqualifications decreased to 17.55%.

It is expected that the more experienced organizer or tenderer is, the higher the level of savings will be. The effect of the number of previous entries in the completed tenders (the experience determines this) is assumed to be non-linear, and therefore, the square root of the number of previous auctions and organizers preceding participation is used. The distribution of more and less experienced organizers for five years is shown in the map in Figure 8 below. Moreover Figure A2 in Appendix A shows the bidders' experience over 2013-2017.

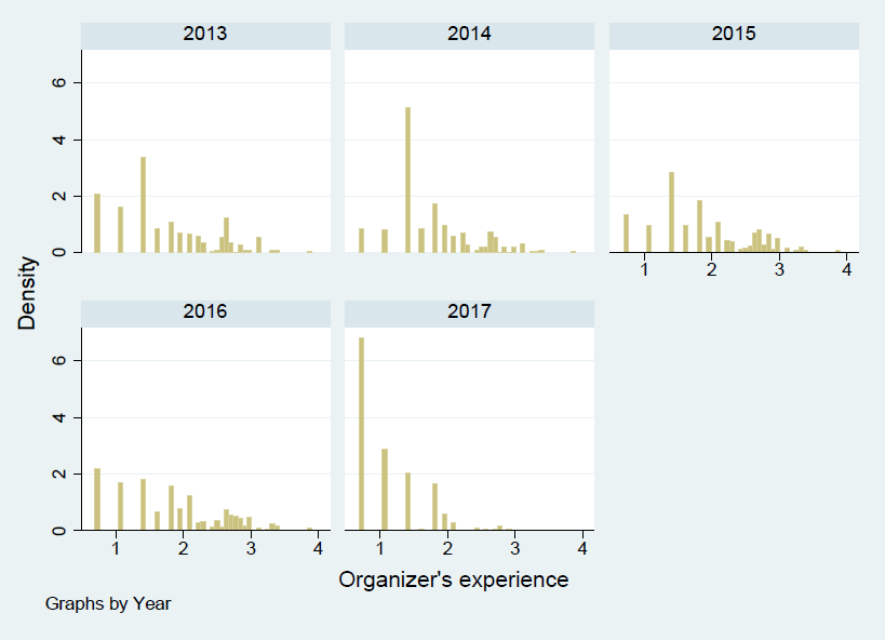


Figure 8. The organizers' experience over five years (2013-2017)

*Chapter 5*

# EMPIRICAL RESULTS

This chapter consists of three parts. First, the results of a linear model with the normality, heteroscedasticity, and multicollinearity tests are presented. Secondly, OLS models for different price categories of medicines were made. Third, in order to avoid heteroscedasticity among drugs, the OLS model for estimating savings on an example of several medicines was used.

Savings from the auction is a phenomenon that depends on a lot of factors, including the cost of the product, transaction costs, the organization of the procurement procedure, and so on. This study only covers the auction itself and, for example, delivery costs of the goods are not the subject of this work. Overall, OLS models explain on average 15.53% of the variation of savings which means that a lot of determinants of auction savings are not included. However, with OLS there were obtained statistically significant results of almost all the explanatory variables. The relationship between savings and the introducing the PROZORRO system as well as the mandatory use of PROZORRO are positively correlated as expected.

The results of the OLS models are presented in further Table 6.

## *5.1. Summary of the OLS model*

The OLS model results presented in Table 6 below shows the relationship between savings and a set of explanatory variables. This model explains on average 15.53%

of the variation of savings which means that the set of used independent variables explains small changes in the efficiency of the auction. The explanation of such a result could be a large variation among the purchasers as well as participants (the organization's size, trade turnover, bidder's advantageous geographic location, etc.), the difference between the medicines (the country where a drug was produced, medical form, volume, and dosage).

Table 6. The OLS model's results

| | OLS | |
|---|---|---|
| | Coef. | se |
| Bidder | 2.0871*** | [0.1388] |
| Bidder, squared | -0.0687*** | [0.0062] |
| lnItem | -0.8497*** | [0.1218] |
| Disqualification | -0.3744 | [0.3106] |
| eAuction | -3.9183 | [7.6356] |
| Time | | |
| Interim | 0.7403 | [0.6984] |
| Mandatory | 9.9382 | [7.6451] |
| Threshold | 1.3526*** | [0.2943] |
| Region | 1.3062*** | [0.3776] |
| Organizer's experience | 1.7385*** | [0.1325] |
| Winner's experience | 0.3751** | [0.1725] |
| Entrepreneur | -18.5418 | [14.3054] |
| lnQuantity | 0.1907*** | [0.0632] |
| lnShare | -0.5738*** | [0.0577] |
| _cons | -3.5737 | [3.8115] |
| N | 56602 | |
| r2 | 0.1553 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

The main goal of this research is an estimation the relationship between the introduction the PROZORRO-system and mandatory maintenance of PROZORRO. So first, the insignificant coefficients of Time as expected shows

that the electronic auction presence on average increases savings by 9.94%. By the way the further models will show the significance relationship between savings and the introducing the PROZORRO system. Secondly, several variables that "changed" the sign of their coefficients are the variables Threshold, Region, and Share.

The other tender characteristics are the number of bidders, the number of drugs in procurement, and the quantity of each drug. The first participant on average increases the savings by 2.02%, and after 16 participants the level of savings begins gradually decline. The coefficients of Item is significant but not major. 1% increase in items of the drugs decreases savings by 0.85 percentage points. The explanation is as follows: the greater the number of medications in the tender, the more difficult it is to find a provider that will offer low prices for all types of medications, while increasing the number of unique drugs leads to an increase in contract price. This statement is confirmed by the coefficient of the variable Share. The higher the cost (contract price divided by the drug cost) of the medication in the tender (increase by 1%), the average savings are smaller (by 0.57 percentage points). The same logic as the drug cost does not work with the Threshold variable. If the amount of the tender exceeds 200,000 UAH, then the savings go down by 1.35%. The variable Quantity has positive significant coefficient. Increasing the quantity of drug by 1% increases savings by 0.19 percentage points. This can be explained by the fact that it is better for the participants to offer a more favorable price for those products, the quantity of which in a lot is larger.

The coefficient of the disqualifications and entrepreneur (FOP) are negative but insignificant. This suggests that presence of the disqualifications as well as the presence of the private entrepreneurs do not affect the change in savings in the sample.

The every month of the procurement procedure is significant. However, the highest savings can be obtained not only in the last quarter. For example, in October the savings on average rise by 2.03% comparing with the first quarter but in November and December savings on average decrease by 3.13% and 1.69% comparing with the first quarter respectively.

The other factor that makes an auction more effective is the experience of both the buyer and the participant. The growth of the experience of the bidder by one more tender participation increases the savings by 0.38%, and the organizer's experience – by 1.74%. This indicates that the purchasers are more likely to get higher savings rather than bidders, and the every organizers' participation gives 5 times bigger effect than the sellers' participation.

In order to verify that the data are satisfied with the OLS assumptions, the normality of residuals, homoscedasticity, model specification, and multicollinearity were checked.

The normality of residuals is illustrated with the kernel density, the standardized normal probability, and the variable quantiles plots in further Figures 9-10 and Figure A7 in Appendix A. Both the standardized probability and the variable quantiles plots have a deviation to the non-normality. However, in the variable quantiles plot, the lower tail tends to non-normality while the upper tail has a normal distribution. In the histogram of the residuals' distribution, the biases are also present in the middle range data and in the left tail. Summing up, the residuals are not close to the normal distribution, and probably the outliers' excluding may partially help with this bias.

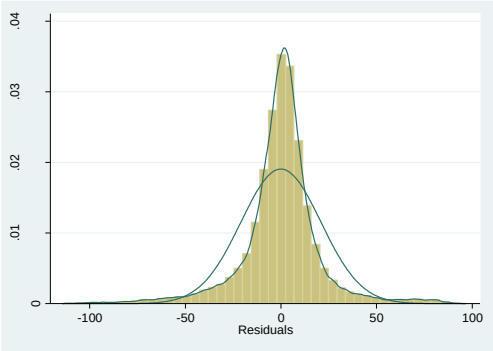


Figure 9. The histogram of the residuals' distribution (left one).

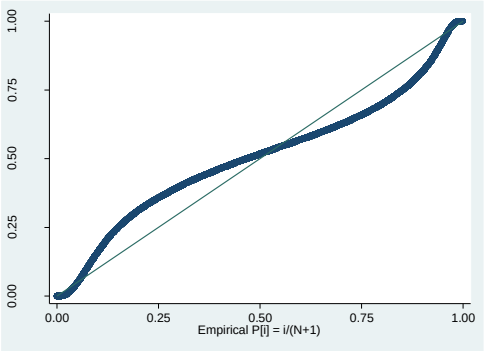


Figure 10. The standardized normal probability (right one)

Shapiro-Wilk W test for normal data based on the assumption of the normal distribution gives a very small p-value. So the null hypothesis could be rejected, and the plots' of residuals confirm the Shapiro-Wilk test results.

In order to make a check on heteroscedasticity two tests were used: the White's test and Breusch-Pagan test. These tests determine whether the residuals' variance is constant or not. Both tests have zero p-value which means that the null hypothesis is rejected, and the residuals' variance is not homogeneous.

The next check is a test of the model specification. The Ramsey RESET test and model specification link test for single equation provide information on whether all the required independent variables have been included in the model. So, the first test checks whether any variables are omitted in the model. Since the p-value from the Ramsey RESET test is very small, therefore the null hypothesis is rejected, and hence a specification error is present. The next test of model specification tries to find the additional statistically significant variable (-s). As long as there are no such additional variables, then the model is properly specified. To perform this test, two new variables are created: the predicted value of the dependent variable – Savings_hat, as well as the new variable Savings_hat in the square. Then, a

dependency model of the variable Savings and two new variables is made. That one may get a model that is well-specified, the results of the model should be as follows: the coefficient of the Savings_hat variable should be statistically significant, since it is a forecast value, while the coefficient of the variable Savings_hat in the square should be statistically insignificant, because it repeats the predicted value. As a result, both coefficients were statistically significant, with a t-statistic of 29.33 and -8.5, respectively. This result shows that the null hypothesis that the model is correctly specified is rejected, and from this, it follows that there is a specification error. This is explained by the fact that in the sample used, the OLS model needs to be changed or another model is required to be specified. Therefore, in the next two sections, the results of models with different sub-samples, in which an attempt was made to correct this deviation, will be presented.

As we can see the insignificant variable Time prompts to make the model separately for the variable Time and eAuction. The reason for this is the presence of the multicollinearity between eAuction and Time. The variance inflation factor (VIF) and the tolerance (1/VIF) were calculated to check for the presence or absence of multicollinearity. Using the rule of thumb which indicates high multicollinearity if VIF of the variable is higher than 10, there were determined next collinear variables – eAuction and Time, number of bidders and bidders, squared, and also the variables which indicate the geographic location (KOATUU, region both the bidder and the organizer). The other check for multicollinearity is the level of the tolerance called the measure of collinearity, which is less than 0.1, if the variable is collinear. Once again the same result was obtained. The table of VIFs and the tolerances are in Table B5 in Appendix B. While the eAuction variable divides the dataset for the pre- and post-PROZORRO period, the variable Time takes into account the pre- and post-PROZORRO periods, as well as separates the period after-PROZORRO into the phase of using the electronic system in the test mode and the implementation of the obligatory use of PROZORRO. The regression

summary using eAuction and Time variables separately is presented in Table B6 (in Appendix B).

By constructing two models, separately with the variables eAuction and Time, the results were almost the same as for the base model with all variables. But some differences still exist so that they will be discussed below.

To begin with, both models, as well as the base model, describe 15.53% variation in savings. The improvement of R^2 was not to take place since the set of control variables was not changed, and the model was built with the initial data set without any changes. However, in a model without a variable eAuction variable Time has become statistically significant. Thus, the appearance of the PROZORRO system, on average, increased its savings by 5.97%, and the fact that the PROZORRO system became obligatory for all participants and purchasers has led to a 6.02% increase in savings.

The variable Entrepreneur in a model with a variables eAuction and Time has the same as in the base model, a negative sign, but is statistically significant. And an presence of the entrepreneur in a tender on average reduces savings by only 18.5%. It should be added that when using the standard errors, the variable Entrepreneur becomes statistically insignificant. Since, because of the presence of heteroscedasticity, the robust standard errors are more reliable than simple standard errors, then the number of items in the tender has a statistically significant relationship with the savings.

It should be noted that the coefficient of the variable Disqualification after the exclusion from the model or the variable eAuction, or the variable Time, still remains insignificant and does not affect the savings at all.

*5.2. Summary of the OLS model for price categories*

The models presented in the previous block showed that there are ways to improve the auction performance model. For this purpose, in this and subsequent sections, OLS models will be considered for estimating savings for certain groups of medicines: in this section there will be presented groups of low-priced medicines, namely 10 groups of medicines with a maximum price of 35 UAH; in the next section, OLS models will be considered for certain types of medicines.

Table 7. The OLS model's results for low price medicines

| Time | Price <3.5 | |
|---|---|---|
| | Coef. | se |
| Bidder | 5.7219*** | [0.9796] |
| Bidder, squared | -0.2031*** | [0.0433] |
| lnItem | -9.0615*** | [1.0228] |
| Disqualification | -4.3126* | [2.2486] |
| eAuction | 8.3373** | [3.8744] |
| Threshold | 0.9959 | [2.5327] |
| Region | 3.925 | [2.7661] |
| Organizer's experience | 6.2691*** | [0.8696] |
| Winner's experience | -2.7050** | [1.2422] |
| lnQuantity | 4.0147*** | [0.7228] |
| lnShare | -3.6579*** | [0.6818] |
| _cons | -15.3325 | [34.2033] |
| N | 2763 | |
| r2 | 0.3769 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

In the following models, savings will be valued for medical products with a price of up to 35 UAH in such a way that the price limit for each group will be 3.5 UAH.

The first price category is the drugs with a price of up to 3.5 UAH. The sample has 2,763 observations from the given price group. The estimation results are presented

in Table 7 above. The model for this price group explains on average 37.69% of the variation of savings, and it is three times bigger than the variation for the base model for the whole sample.

The first participant on average increases the savings by 5.72%, and after 14 participants this result begins to decrease gradually. For example, in tenders with more than 10 participants, the level of savings on average increases significantly more than 50%. In the same time, the presence of disqualifications negatively affects the outcome of the auction. If one or more participants have been disqualified, savings on average are reduced by 4.31%. One of the explanations is the following: participants offering more favorable prices have tender documentation that is not in compliance with the requirements. There is a possibility that in this case the gap between the price of a disqualified bidder and the second lowest price is huge; meanwhile, there could be a lot of the competitive bids in the possible case where the gap is tiny. As a result, the disqualification may result in a positive effect on savings.

It should also be noted that the group of products with a price of up to 3.5 UAH has the smallest impact of the purchaser's experience on saving among all ten models for low-priced medicines. Each completed public procurement will decrease the auction performance by 2.71%.

This model also leads to the different changes in savings during the year; thus the auction efficiency in September is 9.03% higher than in April. The value of this coefficient is the highest among all models for low priced medicines.

The only statistically significant coefficient of the variable Quantity is in the model for the first price category (less than 3.5 UAH). It equals 4.02, which means an increase in savings of 4.02% in the case of an increase in the amount of every drug by 1%.

The coefficient of the eAuction variable is statistically significant for 9 out of 10 models for different groups of low prices. During the use of the electronic system, the average increase in savings varied from 4.19% to 12.2%. Moreover, this increase of savings shows the higher results than in the model for all drugs for 7 out of 10 models. Additionally, the cheapest drugs (from the 10.5 UAH – -14 UAH price group) for organizers are the most effective in the small price group.

In Table B14 in Appendix B shows the results of tests for the normality of residuals, homoscedasticity, multicollinearity, and model specification. It should be noted that all the ten models do not have the multicollinearity bias. The mean VIF is less than 3.04 for all low price categories. The Breusch-Pagan test's p-value for homoscedasticity for the medicines with a price smaller than 3.5 UAH is equal 0.0596 which means that the null hypothesis could not be rejected, and there is no heteroscedasticity bias in the model. The Ramsey RESET test for the model specification shows the following results: five price categories' (10.5-17.5 UAH, and 21-28 UAH) p-values are higher than 0.05 which means that the null hypothesis of the absence of the omitted variables could not be rejected. The Breusch-Pagan test results shows that three models do not have heteroscedasticity bias because the null hypothesis could not be rejected (the p-values are 0.0596, 0.3395, and 0.6328 for the first, fifth, and eights models respectively).Therefore, these models are specified correctly. One can conclude that if some price groups are identified in the sample, on which models will be built and a forecast will be made, then this forecast will give a more accurate result than simultaneously taking into account all the medicines.

*5.3. Summary of the OLS model for specific drugs*

The models presented in the first block are causing to use sub-samples of the specific drugs. These subs-samples have an average of 541 observations. Consequently, using the base model (equation 2) in the example of 5 drugs, an estimation of the savings was made. Among the selected drugs are the following: Analgin, Atropine, L-Lysine Aescinat, Dithylin, and Vicasolum. The characteristics of the preparations are indicated in Table B10 in the Appendices B.

First, the Analgin drug model, on average, describes 58.03% variation of Savings. The first participant brings 3.51% of savings, each next participant also increases the savings, but at a decreasing rate so that after 17 participants the amount of savings from each subsequent participant begins to decline. The unexpected result was received of the variable Region. The significant coefficient of indicating the same regions of the organizer and the bidder is equal 6.1, which is interpreted as an increasing the savings by 6.1%. This can be interpreted, for example, by high transport costs. In the end, statistically significant is the coefficient of the variable Time. The use of PROZORRO has, on average, increased savings by 14.14%, which is significantly higher than the average throughout the sample, and therefore there is a difference in savings not only because of different price groups but also due to different types of medicines, depending on the active ingredient.

Second, the Dithylin drug model has a slightly smaller value of R^2, equal to 0.8218. But at the same time, the effect of the implementation of the PROZORRO system can be seen on this drug. During the electronic auction in the test mode, savings increased by 7.71% compared to the period of the previous auction (however, the coefficient of the variable eAuction is insignificant), and the use of PROZORRO system in an obligatory mode increased the average savings by 12.13%. As noted above, the presence of disqualifications during public

procurement can have a positive effect on savings in the case of several low-priced offers. The availability of disqualifications for the purchase of Ditylin on average savings is increased by 8.84%. It should be added that the increase in the number of different drugs on average reduces savings by 4.84%. As already explained in the chapter of the methodology, the more unique drugs in the tender, the more difficult it is to find a favorable offer at the same time for all medicines. The clarification for this model is as follows: using the robust standard error makes the coefficient of the Time variable insignificant even in the 90% confidence interval.

Third, the Atropine drug model also defines the significant influence of three periods on the level of savings. The period from January to July 2016 has an average savings of 5.94% which are less than before 2016. The statistically insignificant coefficient of the Time variable does not affect savings in this case but it forces to be careful when it comes to increasing savings through the e-auction. Since some drugs may have an adverse effect. Hence for further research it is a field for analysis.

Forth, the L-Lysine Aescinat drug model provides the significant relationship between variable Time and savings. However, the use of the system PROZORRO in the test mode has negative relationship with savings. This model, on average, describes 54.32% of the variation of savings. So the significant on the 95% confidence interval coefficient of variable Time has high value – 4.41%. This case is a big exception because the value of the coefficient of the variable Time in the interim period has a value of -5.21, in the same time the mandatory use of e-auction provides 4.41% higher savings. So the positive effect of the introducing PROZORRO is slightly reduced by the period of the test mode of PROZORRO.

Fifth, the last model for Vicasolum explains 51.14% variation in savings. The variable Item has the sign as was expected, and an increase of the items in a tender decreases savings by the 4.1%. The significant coefficients of the quantity and share

of drug price in the contract price have the following relationship with the savings: the increase of the drug share by 1% on average increases savings by 3.57%, which is unexpectedly and more likely to be an exception, while the increase of the drug quantity by 1% has a positive effect of 6.01%.

The result of the post-estimation tests are presented in the Table B15 in Appendix B. The p-value of the Shapiro-Wilk test for the all drugs is 0.00 which means that the null hypothesis of the normality of residuals is rejected, and the bias of the non-normality of residuals is present in all five models. The model specification test for Analgin drug shows the absence of the bias, that is, p-value is greater than 0.05, and accordingly there are no reasons for the rejection of the null hypotheses. The values of VIF and the tolerance confirm that there is the multicollinearity in the models since the geographical location variables are highly correlated. The homoscedasticity test (Breusch-Pagan test) for the Dithylin drug model do not give grounds for rejecting the null hypothesis of the constant variance. The Analgin drug's model does not have the specification error, while the Dithylin drug's model has constant variance of the residuals and therefore there are ways to improve these models.

*Chapter 6*

# CONCLUSIONS

The purpose of this analysis is to assess the level of savings in the period before and after the implementation of the electronic system PROZORRO in Ukraine. The study is based on the analysis of the drug procurement in the period 2013-2017. The data used includes information on 2,193 government purchases. To estimate the level of savings, the OLS model was used in which the key variables are the eAuction variable indicating the system (electronic or non-electronic) in which the auction was conducted, and the categorical variable Time dividing the procurement period into three parts (pre-PROZORRO period, the existence simultaneous use of two systems, and obligatory use of PROZORRO).

The key variables that influence the change of savings in a model are the variable eAuction (dividing the data into electronic and non-electronic) and the variable Time (dividing the data into three periods: non-electronic auction up to 2015, electronic and non-electronic auction in the period from 2015 to July 2016, and obligatory use of the electronic auction – after July 2016). The following results were obtained: the actual implementation of the electronic system PROZORRO increases the amount of savings by 5.97%, while the obligatory introduction of PROZORRO system increases its savings by 6.02% compared with the period until 2015.

To check if it is possible to improve the above-mentioned model, the following results of the relationship between the appearance of the PROZORRO system and the change of savings for subsamples of drugs, up to 35 UAH (ten models total),

were obtained. The result is an increase in savings in the amount of 4.19-12.2% of the appearance of the e-auction.

Another result is checking whether the model for selected drugs works. By example, Analgin, Atropine, L-Lysine Aescinat, Dithylin, and Vicasolum, it was determined that the obligatory use of the PROZORRO system, on average, increases the savings by 4.41-14.14% for selected drugs; moreover it could be possible to determine such drugs which have a negative effect of the introducing the PROZORRO system in the further research.

In the future, this study can be continued in the direction of constructing a model on grouped drugs for certain characteristics, such as price group definitions, the combination of similar types of drugs. There is also the question of whether the introduction of the PROZORRO system by itself leads to an increase in savings. It is likely that changing the type of auction from the first-price sealed-bid to a three-round dynamic reserve with the previous so-called blind round could also have led to an increase in savings. So the further research could be focused on the estimation of the e-auction and auction type effects separately.

WORKS CITED

Athey Susan, Levin Jonathan, and Seira Enrique. 2011. "Comparing open and sealed bid auctions: Evidence from timber auctions." *The Quarterly Journal of Economics, Oxford University Press* volume 126, no. 1 (February): 207-257.

Bergemann, Dirk, and Johannes Hörner. 2017. "Should First-Price Auctions be Transparent?" Yale University, Department of Economics.

Carayannis, Elias G., and Denisa Popescu. 2005. "Profiling a methodology for economic growth and convergence: learning from the EU e-procurement experience for central and eastern European countries." *Technovation* 25, no. 1 (January): 1-14.

Chegugu, N. R., and K. G. Yusuf. 2017. "Effect of electronic procurement practices on organizational performance in public hospitals in the county government of Uasin Gishu, Kenya." *International Academic Journal of Procurement and Supply Chain Management* 2, no. 3 (April): 16-32.

Croom, Simon R., and Alistair Brandon-Jones. 2005 "Key issues in e-procurement: procurement implementation and operation in the public sector." *Journal of Public Procurement* 5, no. 3 (March): 367-387.

Decarolis Francesco. 2017. "Comparing public procurement auctions." PhD thesis, Boston University, Department of Economics, and EIEF.

Gerits, Edward. 2017. "First price and second price auction mechanics" *Bannerconnect Blog* (blog), March 7, 2017. https://www.bannerconnect.net/first-price-second-price-auction-mechanics/.

Hackney, Ray, Steve Jones, and Andrea Lösch. 2007. "Towards an e-Government efficiency agenda: the impact of information and communication behavior on e-Reverse auctions in public sector procurement." *European Journal of Information Systems* 16, no. 2 (April): 178-191.

Hawking, Paul, Andrew Stein, David C. Wyld, and Susan Foster. "E-procurement: is the ugly duckling actually a swan down under?" *Asia Pacific Journal of Marketing and Logistics* 16, no. 1 (March): 3-26.

Hong, Yili, Chong Wang, and Paul A. Pavlou. 2015. "Comparing open and sealed bid auctions: Evidence from online labor markets." *Information Systems Research* 27, no. 1 (December): 49-69.

Ji Lu, and Li Tong. 2008. "Multi-round procurement auctions with secret reserve prices: theory and evidence." *Journal of Applied Econometrics* 23, no. 7 (November): 897-923.

Joia, Luiz Antonio, and Fuad Zamot. 2002. "Internet-Based Reverse Auctions by the Brazilian Government." *The Electronic Journal of Information Systems in Developing Countries* 9, no. 1 (July): 1-12.

Kastanioti, Catherine, Nick Kontodimopoulos, Dionysis Stasinopoulos, Nikolaos Kapetaneas, and Nikolaos Polyzos. "Public procurement of health technologies in Greece in an era of economic crisis." *Health policy* 109, no. 1 (January): 7-13.

Lunander, Anders. 2002. "Procurement bidding in first-price and second-price, sealed-bid auctions within the common-value paradigm." *Computational Economics* 19, no. 2 (April): 227-244.

Miller, Joshua J. 2014. "From English to first-price sealed bid: An empirical assessment of the change in auction type on experienced bidders." *Review of Economic Perspectives* 14, no. 2 (June): 105-127.

Onur, İlke, Rasim Özcan, and Bedri Kamil Onur Taş. 2012. "Public procurement auctions and competition in Turkey." *Review of industrial organization* 40, no. 3 (May): 207-223.

Panda, Prabir, G. P. Sahu, and Pramod Gupta. 2010. "Promoting transparency and efficiency in public procurement: E-procurement initiatives by government of India." In *7th International Conference on E-Government (ICEG) 2010, IIM Banglore, India*. https://ssrn.com/abstract=1880050.

Pavel, Jan, and Emilia Sičáková-Beblavá. 2013. "Do e-auctions really improve the efficiency of public procurement? The case of the Slovak municipalities." *Prague Economic Papers* 22, no. 1 (March): 111-124.

Rotchanakitumnuai, Siriluck. 2013. "The governance evidence of e-government procurement." *Transforming Government: People, Process and Policy* 7, no. 3 (July): 309-321.

Shalev, Moshe Eitan, and Stee Asbjornsen. 2010. "Electronic reverse auctions and the public sector–Factors of success." *Journal of Public Procurement* 10, no. 3 (December): 428-452.

Soudry, Ohad. 2004 "Promoting economy: Electronic reverse auctions under the EC directives on public procurement." *Journal of Public Procurement* 4, no. 3 (March): 340-374.

Svidronova, Maria Murray, and Juraj Nemec. 2016. "E-Procurement in Self-Governing Regions in Slovakia." *Lex Localis* 14, no. 3 (July): 321-335.

Svidronova, Maria Murray, and Tomas Mikus. 2015. "E-procurement as the ICT innovation in the public services management: case of Slovakia." *Journal of public procurement* 15, no. 3 (March): 317-340.

Vaidya, Kishor, Hernan Riquelme, Junbin Gao, and Jeffrey Soar. 2004 "Implementing e-Procurement Initiatives: Impact of Organisational Learning across the Public Sector." In *Proceedings of 5th International Conference of the Continuous Innovation Network (CINet)*, 397-409. University of Western Sydney.

Walker, Helen, and Christine Harland. 2008. "E-procurement in the United Nations: influences, issues and impact." *International Journal of Operations & Production Management* 28, no. 9 (August): 831-857.

Yukins, Christopher R., and Don Wallace. 2005. "UNCITRAL Considers Electronic Reverse Auctions, as Comparative Public Procurement Comes of Age in the US." *Public Procurement Law Review*, April 27, 2005. http://ssrn.com/abstract=488125.

Zhang, Xiaodan, Zhiwu Li, Yun Huang, and Huajun Tang. 2017. "Performance analysis of reverse auction mechanisms based on Petri nets." *Advances in Mechanical Engineering* 9, no. 9 (September). https://doi.org/10.1177/1687814017724085.

## WEB SOURCES

http://bipro.prozorro.org.ua.

https://ips.vdz.ua.

http://nashigroshi.org/2017/04/28/zakupivelni-tsiny-na-liky-v-ukrajini.

http://zakon3.rada.gov.ua/laws/show/1490-14.

http://zakon5.rada.gov.ua/laws/show/2289-17.

http://zakon5.rada.gov.ua/laws/show/1197-18.

http://zakon5.rada.gov.ua/laws/show/922-19.

http://zakon2.rada.gov.ua/laws/show/240-2014-%D0%BF.

http://zakon2.rada.gov.ua/laws/show/z1097-14.

# APPENDIX A: FIGURES

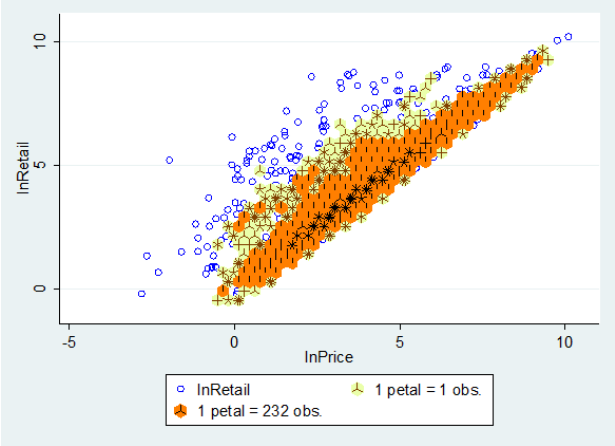


Figure A1. The relationship between retail and auction prices

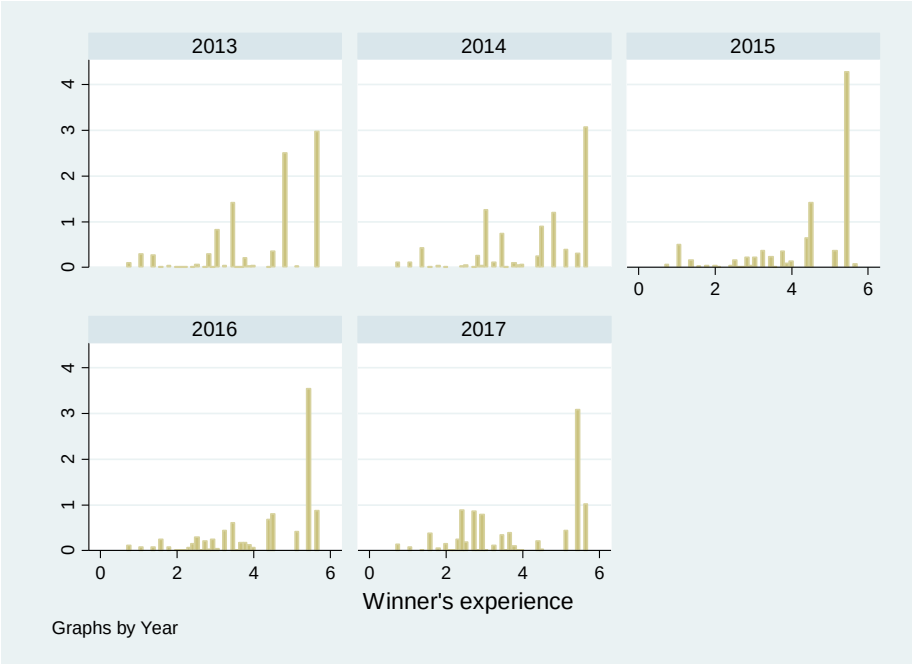


Figure A2. The participant's experience during the period 2013-2017

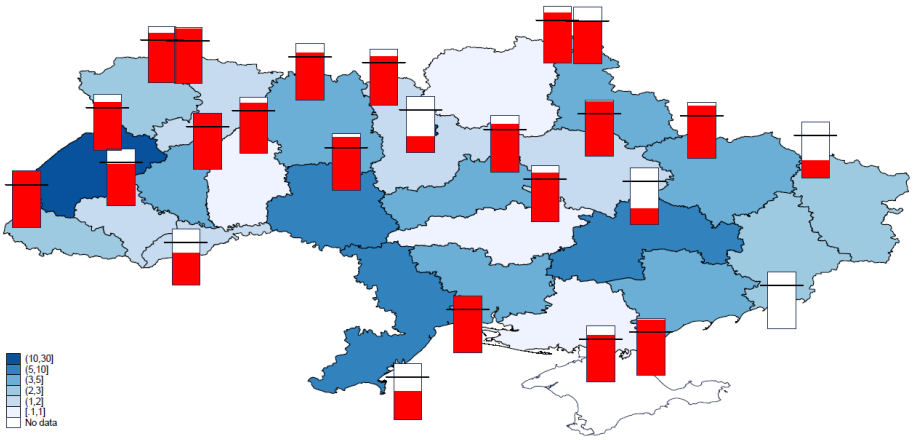


Figure A3. The total number of tenders and the distribution of Region variable bars in 2014

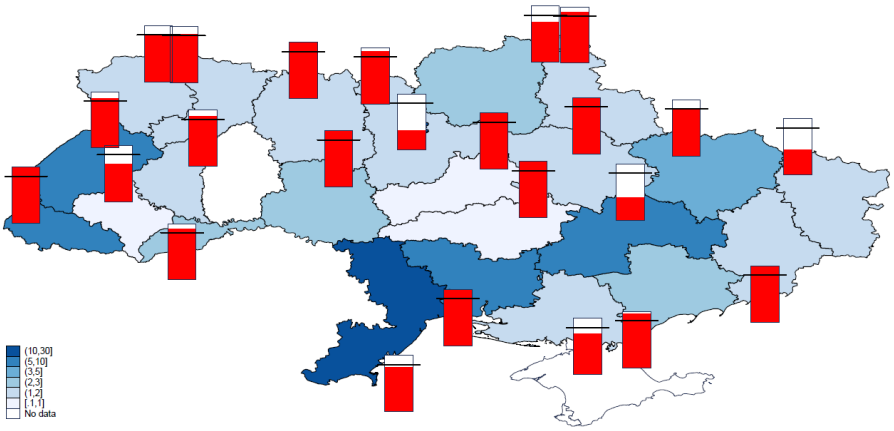


Figure A4. The total number of tenders and the distribution of Region variable bars in 2015

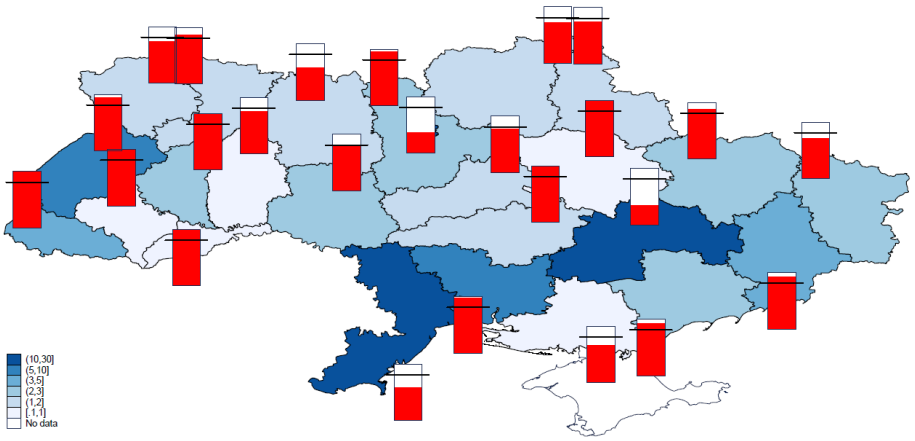


Figure A5. The total number of tenders and the distribution of Region variable bars in 2016

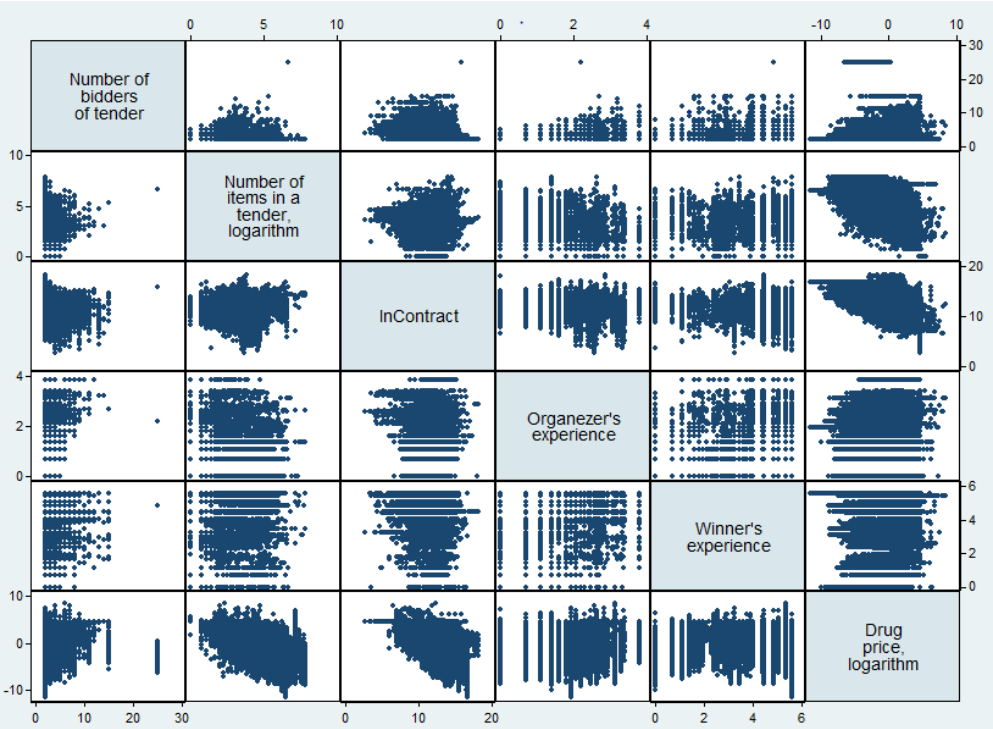


Figure A6. The scatterplot matrices for independent variables during the period 2013-2017

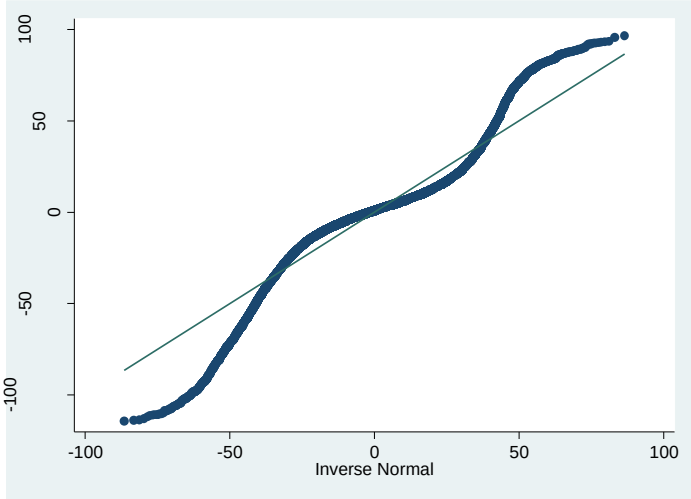


Figure A7. The variable quantiles plot of residuals

# APPENDIX B: TABLES

Table B1. Descriptive statistics of control variables (means) by organizer's region

| | Means | | | | | | |
|---|---|---|---|---|---|---|---|
| | experWin | experOrg | Bidder | log of Contract | log of Quantity | log of Item | log of Share |
| | By Organizer's region / oblast | | | | | | |
| Cherkasy | 4.56 | 1.41 | 2.97 | 12.97 | 3.61 | 5.15 | -1.19 |
| Chernihiv | 2.94 | 1.32 | 3 | 11.92 | 3.18 | 4.53 | -0.71 |
| Chernivtsi | 2.18 | 0.76 | 2.56 | 13.1 | 3.62 | 5.35 | -1.53 |
| Crimea | 1.15 | 0.08 | 2.09 | 12.03 | 2.68 | 4.39 | -1.78 |
| Dnipro | 5.13 | 1.44 | 2.41 | 13.15 | 3.77 | 4.81 | -1.07 |
| Donetsk | 3.24 | 1.03 | 2.23 | 13.42 | 2.35 | 6.17 | -2.85 |
| Ivano-Frankivsk | 2.09 | 1.39 | 2.42 | 14.28 | 2.88 | 5.87 | -3.2 |
| Kharkiv | 4.55 | 1.47 | 2.44 | 13.82 | 3.61 | 5.15 | -1.76 |
| Kherson | 2.3 | 0.85 | 2.51 | 12.31 | 3.22 | 5.18 | -1.37 |
| Khmelnytskyi | 4.84 | 1.18 | 4.59 | 12.87 | 3.97 | 5.31 | -0.61 |
| Kropyvnytskyi | 4.96 | 1.24 | 2.33 | 12.9 | 3.86 | 4.62 | -0.94 |
| Kyiv | 4.18 | 1.67 | 3.03 | 13.23 | 3.95 | 5.11 | -1.07 |
| Lugansk | 3.13 | 1.23 | 2.32 | 13.06 | 2.26 | 5.99 | -2.62 |
| Lviv | 4.91 | 2.23 | 3.87 | 12.62 | 4.48 | 4.9 | 0.17 |
| Mykolaiv | 4.79 | 1.7 | 3.11 | 11.6 | 4.02 | 4.29 | 0.62 |
| Odesa | 4.07 | 2.19 | 3.7 | 12.42 | 4.77 | 4.14 | 0.55 |
| Poltava | 5.15 | 1.59 | 2.34 | 12.47 | 3.4 | 4.98 | -0.79 |
| Rivne | 4.93 | 1.56 | 2.54 | 13.21 | 2.32 | 5.14 | -2.47 |
| Sevastopil | 5.01 | 0.73 | 2 | 12.19 | 4.16 | 4.51 | -0.43 |
| Sumy | 4.29 | 1.18 | 3.33 | 11.32 | 3.76 | 4.05 | 0.53 |
| Ternopil | 5.21 | 1.64 | 2.47 | 13.61 | 2.82 | 6.81 | -2.55 |
| Vinnytsia | 4.25 | 2.06 | 3.99 | 11.99 | 3.82 | 4.73 | 0.18 |
| Volyn | 4.61 | 1.69 | 2.42 | 12.66 | 2.93 | 5.29 | -1.47 |
| Zakarpattya | 4.59 | 1.46 | 3.92 | 13.5 | 4.1 | 5.31 | -1.28 |
| Zaporizhzhia | 5.03 | 1.68 | 2.48 | 12.87 | 3.46 | 5.17 | -1.27 |
| Zhytomyr | 3.83 | 1.6 | 3.45 | 12.27 | 3.86 | 4.33 | -0.22 |

Table B2. Descriptive statistics of control variables (st. dev.) by organizer's region

| Standard deviations | | | | | | | |
|---|---|---|---|---|---|---|---|
| | exper Win | exper Org | Bidder | log of Contract | log of Quantity | log of Item | log of Share |
| By Organizer's region / oblast | | | | | | | |
| Cherkasy | 1.14 | 0.86 | 0.82 | 1.65 | 2.16 | 0.9 | 2.49 |
| Chernihiv | 1.74 | 1 | 1.01 | 1.33 | 1.71 | 1.02 | 1.94 |
| Chernivtsi | 1.56 | 0.85 | 0.87 | 0.92 | 1.57 | 0.97 | 2.1 |
| Crimea | 0.69 | 0.26 | 0.35 | 0.41 | 1.89 | 1.05 | 2.58 |
| Dnipro | 0.93 | 0.8 | 0.85 | 1.73 | 1.76 | 0.98 | 2.15 |
| Donetsk | 0.75 | 0.5 | 0.62 | 1.35 | 1.73 | 1.51 | 2.34 |
| Ivano-Frankivsk | 2.52 | 0.72 | 0.67 | 1.46 | 2.31 | 0.82 | 2.64 |
| Kharkiv | 1.62 | 0.8 | 0.89 | 1.4 | 2.05 | 0.98 | 2.54 |
| Kherson | 2.29 | 0.46 | 0.94 | 0.68 | 1.78 | 1.12 | 1.99 |
| Khmelnytskyi | 1.09 | 0.54 | 1.64 | 1.44 | 1.81 | 1.41 | 2.17 |
| Kropyvnytskyi | 1.11 | 0.57 | 0.63 | 1.44 | 1.83 | 0.77 | 2.02 |
| Kyiv | 0.95 | 1.12 | 2 | 1.64 | 1.97 | 1.26 | 2.53 |
| Lugansk | 1.37 | 1.07 | 0.93 | 1.24 | 1.7 | 0.95 | 2.14 |
| Lviv | 1 | 0.75 | 1.83 | 1.36 | 1.86 | 0.84 | 2.02 |
| Mykolaiv | 1.23 | 0.93 | 1.69 | 1.99 | 1.88 | 0.95 | 2.96 |
| Odesa | 1.12 | 0.95 | 1.94 | 2.25 | 1.9 | 0.89 | 2.45 |
| Poltava | 1.02 | 1.07 | 0.71 | 0.82 | 1.88 | 1.11 | 2.2 |
| Rivne | 1.15 | 0.52 | 1.22 | 1.07 | 2.34 | 1.25 | 3.23 |
| Sevastopil | 1.52 | 0.52 | 0 | 1.17 | 1.44 | 0.57 | 1.38 |
| Sumy | 1.81 | 0.9 | 1.57 | 1.79 | 1.95 | 0.83 | 2.45 |
| Ternopil | 0.62 | 0.51 | 1.22 | 1.23 | 1.56 | 1.3 | 2.16 |
| Vinnytsia | 1.66 | 0.86 | 1.67 | 1.3 | 1.8 | 1.13 | 2.14 |
| Volyn | 1.26 | 0.39 | 1.07 | 1.31 | 1.77 | 1.27 | 2.26 |
| Zakarpattya | 1.26 | 0.67 | 5.83 | 1.37 | 1.82 | 0.96 | 2.17 |
| Zaporizhzhia | 0.63 | 0.67 | 0.89 | 1.59 | 1.79 | 1.11 | 2.38 |
| Zhytomyr | 1.15 | 0.65 | 1.55 | 1.38 | 1.93 | 0.9 | 1.95 |

Table B3. The correlations between Savings and the control variables in before-PROZORRO period

| | Savings | Bidder | Item | Region | Entrep reneur | exper Win | exper Org | Disq-n |
|---|---|---|---|---|---|---|---|---|
| Savings | 1 | | | | | | | |
| Bidder | .0861 | 1 | | | | | | |
| Item | -.0562 | -.1285 | 1 | | | | | |
| Region | .0777 | .1356 | -.0426 | 1 | | | | |
| Entrepre neur | -.0065 | -.0026 | -.0045 | .0060 | 1 | | | |
| experWin | .1187 | -.0088 | -.0121 | **.5225** | -.0080 | 1 | | |
| experOrg | .1274 | **.2947** | -.1058 | .0088 | .0050 | .0190 | 1 | |
| Disq-n | .0762 | **.3438** | **-.1689** | .0727 | -.0028 | -.0704 | **.1767** | 1 |

Note: bold are those correlations which >15%

Table B4. The correlations between Savings and the control variables in a period of the test mode of PROZORRO

| | Savings | Bidder | Item | Region | exper Win | exper Org | Disq-n |
|---|---|---|---|---|---|---|---|
| Savings | 1 | | | | | | |
| Bidder | **.2326** | 1 | | | | | |
| Item | -.0685 | -.0994 | 1 | | | | |
| Region | -.0322 | .0885 | **.3742** | 1 | | | |
| experWin | .1501 | **-.2962** | **.2257** | **.2071** | 1 | | |
| experOrg | .1413 | **.4177** | **-.2192** | **-.3016** | **-.3100** | 1 | |
| Disqualification | .0549 | **.4842** | -.1144 | .1341 | -.1275 | .0450 | 1 |

Note: bold are those correlations which >20%

Table B5. The VIF and tolerance (1/VIF) for general model

| Variable | VIF | 1/VIF | Variable | VIF | 1/VIF |
|---|---|---|---|---|---|
| eAuction | 723.73 | 0.0014 | ExperWin | 9.09 | 0.11 |
| Time (Interim) | 1.6 | 0.626 | Region | 4.89 | 0.2045 |
| Time (Mandatory) | 724.72 | 0.0014 | Disqualification | 2.01 | 0.4985 |
| Bidder | 10.37 | 0.0964 | ExperOrg | 2.04 | 0.4895 |
| Bidder2 | 8.73 | 0.1145 | Entrepreneur | 30.97 | 0.0323 |
| lnShare | 2.98 | 0.3355 | lnQuantity | 2.2 | 0.4546 |
| Threshold | 2.16 | 0.4629 | lnItem | 3.5 | 0.2858 |
| Mean VIF: 96.28 | | | | | |

Table B6. The OLS robust models' results for eAuction and Time variables

| | OLS_robust ( eAuction) | | OLS_robust ( Time) | |
|---|---|---|---|---|
| | Coef. | se | Coef. | se |
| Bidders | 2.0825*** | [0.1503] | 2.0849*** | [0.1503] |
| Bidders, squared | -0.0686*** | [0.0062] | -0.0686*** | [0.0062] |
| lnItem | -0.8538*** | [0.1410] | -0.8487*** | [0.1413] |
| Disqualification | -0.3561 | [0.3040] | -0.3701 | [0.3041] |
| eAuction | 5.9675*** | [0.4278] | | |
| Time | | | | |
| Interim | | | 0.7142 | [0.6519] |
| Mandatory | | | 6.0223*** | [0.4285] |
| Threshold | 1.3552*** | [0.3114] | 1.3502*** | [0.3114] |
| Region | 1.3092*** | [0.3977] | 1.3033*** | [0.3976] |
| Organizer's experience | 1.7437*** | [0.1440] | 1.7402*** | [0.1441] |
| Winner's experience | 0.3672** | [0.1863] | 0.3747** | [0.1865] |
| Entrepreneur | -18.5232*** | [1.7002] | -18.5335*** | [1.6999] |
| lnQuantity | 0.1902*** | [0.0710] | 0.1909*** | [0.0711] |
| lnShare | -0.5737*** | [0.0651] | -0.5740*** | [0.0651] |
| _cons | -3.4617 | [4.4220] | -3.5715 | [4.4168] |
| N | 56602 | | 56602 | |
| r2 | 0.1553 | | 0.1553 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B7. The OLS model's results for low price categories (lower 14 UAH)

| Time | 3.5<Price <7 | | 7<Price <10.5 | | 10.5<Price <14 | |
|---|---|---|---|---|---|---|
| | Coef. | se | Coef. | se | Coef. | se |
| Bidder | 2.4070*** | [0.6134] | 1.7582*** | [0.6270] | 1.7144*** | [0.5519] |
| Bidder, squared | -0.0786*** | [0.0271] | -0.0419 | [0.0281] | -0.0624*** | [0.0238] |
| lnItem | -2.2462*** | [0.5780] | -2.3857*** | [0.5607] | -0.601 | [0.5027] |
| Disq-n | -0.0181 | [1.3677] | 0.8194 | [1.3529] | 0.5149 | [1.1876] |
| eAuction | 6.9345** | [2.8177] | 9.5627*** | [2.4401] | 12.1976*** | [2.1602] |
| Threshold | -0.8034 | [1.5362] | -1.4198 | [1.5337] | -2.081 | [1.3653] |
| Region | 5.1757*** | [1.6592] | 3.1491* | [1.6353] | 4.6188*** | [1.4082] |
| Organizer's experience | 1.6580*** | [0.5496] | 1.3902** | [0.5636] | 1.9448*** | [0.5006] |
| Winner's experience | -0.8226 | [0.8562] | -0.9719 | [0.7732] | 0.688 | [0.6502] |
| lnQuantity | -0.4543 | [0.4583] | -1.2657*** | [0.4503] | -0.412 | [0.3971] |
| lnShare | -0.6677 | [0.4411] | 0.0411 | [0.4406] | 0.1263 | [0.3857] |
| _cons | 13.0124 | [15.1810] | 20.5722 | [13.2619] | -7.1277 | [12.2187] |
| N | 4202 | | 4104 | | 3833 | |
| r2 | 0.2271 | | 0.2257 | | 0.2436 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B8. The OLS model's results for low price categories (14-24.5 UAH)

| Time | 14<Price <17.5 | | 17.5<Price <21 | | 21<Price <24.5 | |
|---|---|---|---|---|---|---|
| | Coef. | se | Coef. | se | Coef. | se |
| Bidder | 2.1847*** | [0.5136] | 1.2868** | [0.6286] | 1.7698** | [0.7115] |
| Bidder, squared | -0.0709*** | [0.0224] | -0.0301 | [0.0280] | -0.0502* | [0.0303] |
| lnItem | -1.0031** | [0.4823] | 1.1751** | [0.5698] | -0.9617 | [0.6587] |
| Disq-n | 0.2745 | [1.0848] | 1.2652 | [1.3489] | -0.2005 | [1.4984] |
| eAuction | 8.4199*** | [1.6960] | 5.3258*** | [1.9947] | 6.6275*** | [2.0976] |
| Threshold | 1.6312 | [1.2714] | 1.6397 | [1.5827] | 0.7562 | [1.7367] |
| Region | 1.5106 | [1.3233] | 2.1242 | [1.6560] | 4.9206*** | [1.7989] |
| Organizer's experience | 1.9713*** | [0.4824] | 0.6893 | [0.5800] | 0.9116 | [0.6726] |
| Winner's experience | 0.9288 | [0.6912] | 0.8584 | [0.7526] | 0.2533 | [0.8369] |
| lnQuantity | 0.3188 | [0.3864] | -0.8538* | [0.4802] | -0.5396 | [0.5455] |
| lnShare | -0.9198** | [0.3738] | 0.7748* | [0.4654] | -0.7726 | [0.5399] |
| _cons | -7.0989 | [12.9028] | 20.0432 | [17.2569] | -7.07 | [17.3131] |
| N | 3515 | | 2779 | | 2319 | |
| r2 | 0.2514 | | 0.2657 | | 0.2619 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B9. The OLS model's results for low price categories (24.5-35 UAH)

| Time | 24.5<Price <28 | | 28<Price <31.5 | | 31.5<Price <35 | |
|---|---|---|---|---|---|---|
| | Coef. | se | Coef. | se | Coef. | se |
| Bidder | 2.4318*** | [0.8461] | 2.2603*** | [0.8213] | 3.1558*** | [0.8764] |
| Bidder, squared | -0.0992*** | [0.0372] | -0.0922*** | [0.0353] | -0.1046*** | [0.0371] |
| lnItem | 0.3327 | [0.7516] | -0.1783 | [0.7774] | 2.3082*** | [0.8471] |
| Disqualification | -1.0911 | [1.6735] | 1.2462 | [1.7338] | -2.7962 | [1.8397] |
| eAuction | 8.4211*** | [2.5197] | 4.1884* | [2.4012] | 1.9318 | [2.6711] |
| Threshold | 0.3798 | [2.0680] | 0.1122 | [2.0772] | 0.7353 | [2.2355] |
| Region | -1.7622 | [2.0805] | -2.1041 | [2.1627] | 4.6641* | [2.4909] |
| Organizer's experience | 2.0976*** | [0.7645] | 3.1138*** | [0.7608] | 1.3607* | [0.7729] |
| Winner's experience | 0.8981 | [0.9229] | -0.7826 | [0.9594] | 0.6671 | [1.0780] |
| lnQuantity | -0.2188 | [0.6322] | -0.6345 | [0.6768] | -1.0502 | [0.7088] |
| lnShare | 0.2151 | [0.6135] | 1.0793* | [0.6501] | 1.4251** | [0.6937] |
| _cons | -3.175 | [17.6332] | -29.3968 | [24.1502] | 46.8850* | [25.3653] |
| N | 1826 | | 1817 | | 1507 | |
| r2 | 0.2639 | | 0.2714 | | 0.2881 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B10. The list of medicines for Chapter 6

| Number in sample | Drug | Medical form, dosage |
|---|---|---|
| 002462 | ANALGIN | sol. for inj. 500 mg/ml amp. 2 ml, blister in the box, #10 |
| 008826 | ANALGIN | rectal suppository 0,1 g blister, #10 |
| 009934 | ANALGIN | rectal suppository 0,25 g blister, #10 |
| 010739 | ANALGIN | tabs 500 mg cont. cell-fr. pack, #10 |
| 014578 | ANALGIN | tabs 0,5 g blister, #6 |
| 007234 | ANALGIN | sol. for inj. 500 mg/ml amp. 1 ml, by box, #10 |
| 004694 | ANALGIN | tabs 500 mg blister, #10 |
| 006515 | ATROPINE | sol. for inj. 1 mg/ml amp. 1 ml, box, #10 |
| 006361 | ATROPINE | drops, eye 10 mg/ml flask 5 ml |
| 007102 | ATROPINE | sol. for inj. 1 mg/ml amp. 1 ml, pack, #10 |
| 006351 | DITHYLIN | sol. for inj. 20 mg/ml amp. 5 ml, contour cell wrap, pack, #10 |
| 000015 | L-LYSINE AESCINAT | sol. for inj. 1 mg/ml amp. 5 ml, blister in a pack, #10 |
| 002886 | VICASOLUM | sol. for inj. 10 mg/ml amp. 1 ml, contour cell wrap, pack, #10 |

Table B11. The OLS robust model's results for Analgin, Atropine

| Time | Analgin | | Atropine | |
|---|---|---|---|---|
| | Coef. | se | Coef. | se |
| Bidder | 3.6095*** | [0.9898] | 3.4701*** | [1.3150] |
| Bidder, squared | -0.1047** | [0.0426] | -0.1237** | [0.0596] |
| lnItem | -2.5864** | [1.2041] | -2.3569* | [1.3770] |
| Disqualification | 3.9081* | [1.9986] | -0.1092 | [2.6988] |
| eAuction | | | 12.0735*** | [4.0569] |
| Time | | | | |
| Interim | 1.0947 | [4.4308] | | |
| Mandatory | 14.1354*** | [3.2259] | | |
| Threshold | 7.3380*** | [2.6366] | 13.1496*** | 7.3380*** |
| Region | 6.1010** | [2.4331] | 7.0971** | 6.1010** |
| Organizer's experience | 0.7287 | [1.2936] | 1.8096 | 0.7287 |
| Winner's experience | -1.6978 | [1.2456] | -2.6577 | -1.6978 |
| lnQuantity | 3.2497*** | [0.7305] | 6.5390*** | 3.2497*** |
| lnShare | -3.1263*** | [0.6623] | -3.4355*** | -3.1263*** |
| _cons | -4.6349 | [13.0866] | -58.1696*** | -4.6349 |
| N | 1107 | | 601 | 1107 |
| r2 | 0.5803 | | 0.514 | 0.5803 |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B12. The OLS robust model's results for Dithylin, L-Lysine Aescinat

| Time | Dithylin | | L-Lysine Aescinat | |
|---|---|---|---|---|
| | Coef. | se | Coef. | se |
| Bidder | 5.2221 | [3.9287] | 0.9292 | [0.7146] |
| Bidder, squared | -0.2611 | [0.3564] | -0.023 | [0.0324] |
| lnItem | -4.8347* | [2.4741] | -0.21 | [0.6298] |
| Disqualification | 8.8436* | [5.2529] | 0.8165 | [1.1996] |
| Time | | | | |
| Interim | 7.7143 | [11.4244] | -5.2117** | [2.2489] |
| Mandatory | 12.1312 | [7.9652] | 4.4068** | [1.9282] |
| Threshold | 4.5017 | [6.1742] | 3.3843 | [3.0041] |
| Region | -1.6982 | [5.8002] | 0.0106 | [1.5285] |
| Organizer's experience | 0.1497 | [3.5177] | 0.6674 | [0.5527] |
| Winner's experience | -2.0582 | [2.8995] | 0.4315 | [0.8989] |
| lnQuantity | 0.7493 | [3.0205] | 2.1447* | [1.2357] |
| lnShare | -0.7281 | [2.6093] | -1.5009 | [1.1758] |
| _cons | 29.2183 | [27.8153] | -8.7234 | [13.7898] |
| N | 188 | | 454 | |
| r2 | 0.8218 | | 0.5432 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B13. The OLS model's results for Vicasolum

| Time | Vicasolum | |
|---|---|---|
| | Coef. | se |
| Bidder | 0.9324 | [1.5994] |
| Bidder, squared | -0.0402 | [0.0605] |
| lnItem | -4.0958** | [1.9726] |
| Disqualification | 0.6162 | [3.0803] |
| Time | | |
| Interim | 3.7095 | [4.7079] |
| Mandatory | 8.5998** | [4.0224] |
| Threshold | 6.0249 | [4.2711] |
| Region | -1.2535 | [4.2046] |
| Organizer's experience | 2.3587 | [1.6840] |
| Winner's experience | 1.0557 | [2.6656] |
| lnQuantity | 6.0068*** | [2.1721] |
| lnShare | -3.5669** | [1.6534] |
| _cons | -14.8481 | [20.1129] |
| N | 355 | |
| r2 | 0.5114 | |

Note: Standard deviations in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%
Monthly, region, and KOATUU dummies are included.

Table B14. The p-values of the tests' results for low price categories

| | Normality of residuals | Homoscedasticity | Model specification | Multicollinearity |
|---|---|---|---|---|
| Models | Shapiro-Wilk test | Breusch-Pagan test | Ramsey RESET test | Mean VIF |
| P<3.5 | 0.00 | 0.0596 | 0.0002 | 30.89 |
| 3.5<Price <7.0 | 0.00 | 0.00 | 0.0056 | 31.38 |
| 7.0<Price <10.5 | 0.00 | 0.00 | 0.0395 | 32.93 |
| 10.5<Price <14.0 | 0.00 | 0.00 | 0.1531 | 37.52 |
| 14.0<Price <17.5 | 0.00 | 0.3395 | 0.1269 | 37.29 |
| 17.5<Price <21.0 | 0.00 | 0.00 | 0.0183 | 30.40 |
| 21.0<Price <24.5 | 0.00 | 0.00 | 0.1231 | 35.55 |
| 24.5<Price <28.0 | 0.00 | 0.6328 | 0.1745 | 22.80 |
| 28.0<Price <31.5 | 0.00 | 0.00 | 0.0546 | 29.05 |
| 31.5<Price <35.0 | 0.00 | 0.0157 | 0.0001 | 30.47 |

Table B15. The p-values of the tests' results for selected medicines

| | Normality of residuals | Homoscedasticity | Model specification | Multicollinearity |
|---|---|---|---|---|
| Models | Shapiro-Wilk test | Breusch-Pagan test | Ramsey RESET test | Mean VIF |
| Analgin | 0.00 | 0.00 | 0.0928 | 24.23 |
| Atropine | 0.00 | 0.00 | 0.00 | 16.62 |
| L-Lysine Aescinat | 0.00 | 0.00 | 0.00 | 13.16 |
| Dithylin | 0.00 | 0.3978 | 0.00 | 13.43 |
| Vicasolum | 0.00 | 0.00 | 0.00 | 14.81 |