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META-ANALYSIS: EFFECT OF CENTRAL BANK'S KEY POLICY RATE ON BANKS' LENDING INTEREST RATES

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ABSTRACT

The importance of the key policy rate is hard to underestimate. By lowering the policy rate, the central bank reduces the cost of borrowing, which stimulates investment and consumption. However, firms and consumers, who are the agents in the process, do not borrow directly from the central bank – they take out loans from commercial banks. Thus, in order to realize the central bank's potential impact on the economy, it is important to analyses the first step of the pass-through: from the key policy rate to commercial lending rates. Is there a strong connection? The goal of our paper is to provide the answer to that question.

Key words: meta-analysis, key policy rate, lending rate, central bank

JEL classifications: C12, C83, E58, E50

1. Introduction

The macroeconomic theory predicts that the key policy rate positively affects banks' lending rates. However, in reality this connection might not be tight. The lending interest rates depend upon many other factors (such as the interbank rate, bond rates, bank market concentration, gross economic savings, dollarization, economic cycle, etc.). The notion that a positive link exists between the key policy rate and lending rate might arise due to the publication bias. While the majority of the literature suggests that the effect of key policy rate on bank lending rate is positive, the views on the size of the effect are conflicting. For example, the estimated connection between the key rate and lending rate in Nigeria does not statistically differ from zero in one of the specifications, suggesting that the connection is positive but weak (Kelilume, 2014). However, from various estimates by Madaschi et al. (2017), we can conclude that interest rate pass-through holds strongly in Swedish and Danish markets.

The transmission mechanism from the key rate to commercial rates is depicted in Figure 1. The commercial banks earn money from lending operations, but they need to borrow funds first. They borrow

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from consumers and other banks, and sometimes from the central bank. Thus, the commercial lending rates of banks depend on the deposit rates, interbank (or money market) rates and the key policy rate.

The policy interest rate has a direct effect on the money market rate, as noted in Figure 1. The effect of the key policy rate on lending interest rates is reinforced through this channel.

The transmission from key policy rate to interbank rates occurs within three mechanisms. Firstly, the central bank can supply reserves to commercial banks through refinancing operations at the key policy rate. Secondly, the CB lends reserves through the marginal lending facility at a marginal lending rate, which is set at a spread above the key policy rate. Thirdly, it accepts reserves as deposits at a reserve deposit rate, which is somewhat below the key rate. This way, the overnight interbank interest rates on reserves are kept in the defined corridor between lending and deposit interest rates.

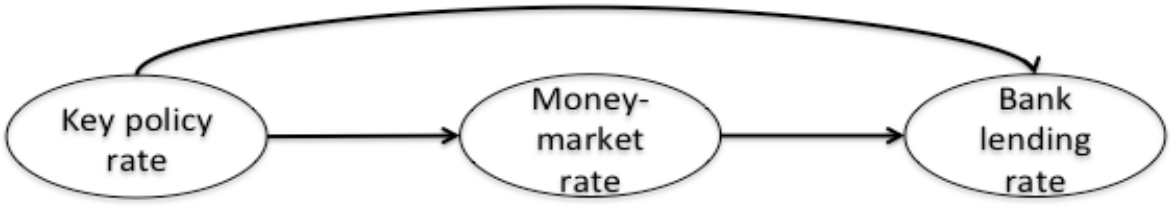

Figure 1. The pass-through from key policy rate to bank lending rate

Different studies investigate the effect of the key policy rate on both lending and deposit rates, but we focused our attention only on the lending rate. The meta-analysis approach allowed us to investigate both how coefficients differ across countries and how different the estimation methodologies are.

The traditional pass-through model considers the monetary policy rate to be a direct determinant of retail bank rates (lending and deposit), assuming that the risk level is low and that financial institutions are well capitalized. This might not be true in less developed countries, which is why in these countries the bank lending rate might be less tightly connected to the key policy rate.

The paper is organized as follows: Section 2 outlines the data collection procedure and provides the descriptive statistics. Section 3 provides the analytical framework. In Section 4, the true effect is estimated, and the effect of publication bias is tested. Finally, in Section 5 there is a summary of the main findings and analysis of the further implications of the conducted research.

2. Data collection procedure and descriptive statistics

In this paper, we quantitatively surveyed the studies that describe the influence of key policy rate on lending rates. Initially, we found 13 research articles. Then we eliminated the papers that describe the influence of key policy rate on money market rates, which is not the topic of our research. We also excluded papers that lacked the estimates of the standard errors. Despite being eliminated from the investigation, the coefficients and models used in the omitted articles do not have much of an influence on the estimation results when adding them into the model, because they use the same set of models and all had positive coefficient estimates. Therefore, the conclusion was reached that there was no use in including the eliminated

articles in the subsequent investigation technique.

We collected the estimated coefficients of exogenous variables included with a different time lags: 0, 1 and 2. Sometimes we came up with regression specifications that, besides having the policy rate, also included money market rates. In this case, the beta-coefficients of the key policy rate would measure its effect aside from the indirect channel of the transmission mechanism (see Figure 1). We excluded such specifications from the analysis because our estimates of interest were of the effect of the key policy rate on bank lending rates through all the existing channels. It should be noted that in some cases the regression specification included several exogenous variables of interest at a different time lag. We decided to pool all the corresponding coefficients into the data set of estimates. When variables of interest were included in first differences, we did not collect the estimates.

In the collected studies, the following models were used: ordinary least squares (OLS), vector auto regression (VAR), structural vector error correction model (VEC), threshold autoregressive models (TAR) and autoregressive distributed lag (ARDL)

Since there are various methods used in the papers under investigation, one could create specific dummy variables so as to determine how coefficients vary depending on the chosen model, as in Kohler et al. (2017). However, our sample size did not allow for such analysis, so there is room for further investigation.

Our models of interest have general form:

$$lr = \beta_0 + \beta_1 mr + \beta_i X + e_t \quad (1)$$

where lr is a proxy for the bank lending rate: maximum or prime lending rates, or average of the rates, etc. (short- or long-term),

mr is a key policy rate, included at different time lags,

X is a vector of control variables that affect the bank lending rate, which does not include the money market rate,

e_t is a stochastic error term.

After all the eliminations, we ended up with 7 articles and 36 estimates (see Table 1). They describe the bank markets of Pakistan, Ghana, India, Nigeria, Kenya, Sweden, and Denmark. Six papers use monthly data, and one paper (number 6 in Table 1) uses annual data. Six papers use data aggregated at country level, and one estimates the effect of the key rate on lending rates of individual banks (3 in Table 1). All but one of the selected papers use data sets that cover the period from 1997 to 2015. One paper covers the period that starts in 1970.

Table 1. Summary statistics of the papers used

Paper	Number of estimates	Country	Period
D. V. S. Sastry, Balwant Singh, Kaushik Bhattacharya. (2009). *Stability of lending rate stickiness: A case study of India*	16	India	1997–2006
Hasan Muhammad Mohsin. (2011). *Impact of monetary policy on lending and deposit rates in Pakistan: Panel data analysis*	1	Pakistan	2001–2011
Augustine Addo, ZuKwame A. Seyram. (2013). *Central bank's policy rate on the cost of borrowing from some selected commercial banks in Ghana*	10	Ghana	2007–2011
Christophe Madaschi, Irene Pablos Nuevo. (2017). *The profitability of banks in a context of negative monetary policy rates: The cases of Sweden and Denmark*	4	Sweden; Denmark	2005–2016
Ikechukwu Kelilume. (2014). *Effects of the monetary policy rate on interest rates in Nigeria*	2	Nigeria	2007–2012
Adeyemi A. Ogundipe, Philip O. Alege. (2013). *Interest rate pass-through to macroeconomic variables: The Nigerian experience*	2	Nigeria	1970–2011
Muchiri Edith Nyambura. (2012). *The impact of Central Bank of Kenya rates on market interest rates of commercial banks in Kenya*	1	Kenya	2008–2012

The selected papers estimate the effect of the policy interest rate on bank lending rate in the presence of other determinants. Out of the 36 estimates in our sample, 24 (67% of the sample) are positive and statistically significant at the 10% confidence level, 3 (8%) are positive but insignificant, 6 (17%) are negative and significant estimates, and 3 (8%) are negative but insignificant.

3. Methodology

We followed the procedure presented in Havranek, Horvath and Valickova (2013) to analytically summarize the collected estimates. To analyse standardized effect sizes, we transform the estimates into partial correlation coefficients (PCC), which take values from -1 to 1. High absolute value of PCC indicates a high degree of association.

$$PCC = \frac{t}{\sqrt{t^2+df}} \quad (2)$$

The standard error of PCC is calculated by:

$$SE_{PCC} = \frac{PCC}{t} \quad (3)$$

The z-score is calculated by the following formula:

$$Z_{PCC} = \frac{1}{2}\ln(\frac{1+PCC}{1-PCC})PCC = \frac{t}{\sqrt{t^2+df}} \quad (4)$$

We analysed the central tendency of effect sizes and partial correlation coefficients using Card's methodology (2012). Table 2 summarizes the calculated measures.

Table 2. Partial correlation coefficients for the relation between key policy rate and bank lending rate

Observations	
Number of studies	7
Number of estimates	36
Average partial correlation coefficients PCC	
Simple average PCC	0.250
Median PCC	0.297 (significance level not computed)
Fixed-effects average PCC	0.278 ***
Random-effects average PCC	0.253 ***

*Note: * denotes significance at the 10%, ** – at the 5%, *** – at the 1% level.*

According to simple average PCC, the effect of policy rate on lending rate is positive and statistically insignificant. However, simple average ignores the fact that some estimates are more precise than others. Both fixed- and random-effect averages control for the precision of the estimates, assigning more weight to estimates that are more precise. Fixed-effects average considers sample standard deviation as the only source of imprecision in the estimates. Random-effects average also controls for population variance, as stated in Card (2012). According to both fixed-effects and random-effects averages of PCC, the effect on the key policy rate of lending rate is positive and statistically significant.

According to Doucouliagos C. (2011), PCC is considered 'small' if the absolute value is between 0.07 and 0.17 and 'large' if the absolute value is greater than 0.33. If the PCC lies between 0.17 and 0.33, the effect is assumed to be 'medium'. From our average estimates, the effect of policy rate of lending rate is of medium size.

4. Publication bias

According to Balima et al. (2017), publication bias is 'a very common tendency among editors, reviewers, and/or researchers to prefer results that are consistent with the most commonly-held views in the field (Type I bias) or that are statistically significant (Type II bias).

Publication bias might potentially lead to published literature being not representative of the phenomenon, and to an overestimation of the effect size compared to the case when all studies are

considered. Publication bias might potentially arise in our topic, with studies finding no statistical effect (Type II bias), or negative effect (Type I bias) being less likely to be published. One of the ways to manage publication bias is to use the funnel plot approach.

Following the procedure proposed by Egger et al. (1997), we analyse funnel plot asymmetry. Some authors use this to analyse publication bias, although there are those who criticize this method because of statistical validity issues (Sterne, 2011). On the horizontal axis, the funnel plot displays PCC; on the vertical axis, it has the precision of the estimates (standard errors in reverse order in Figure 2 and degrees of freedom in Figure 3).

Both figures have the normal shape, with less precise estimates scattered wider around the mean than the more precise estimates. The dots are more scattered around the mean than the pseudo-confidence intervals suggest. This indicates that our data set is heterogeneous. We believe that this could arise due to pooling studies on drastically different countries and time periods (Table 1). However, a formal assessment of the causes of the variations is outside of the scope of our work.

The observations seem to be symmetrically distributed around the mean in both figures, suggesting that publication bias is not likely to be the issue. However, a formal statistical test of funnel plot asymmetry is still in need.

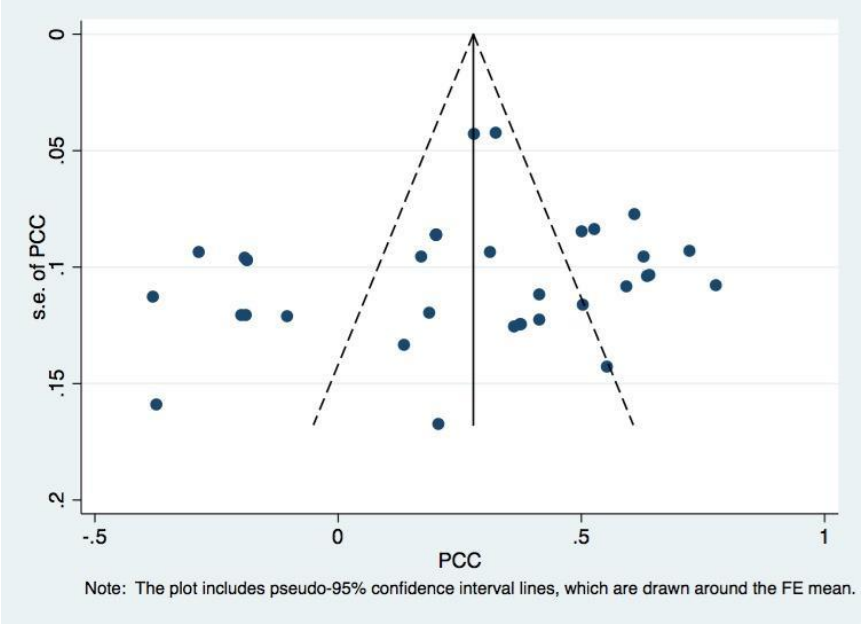

Figure 2. The funnel plot with standard errors in inverse order

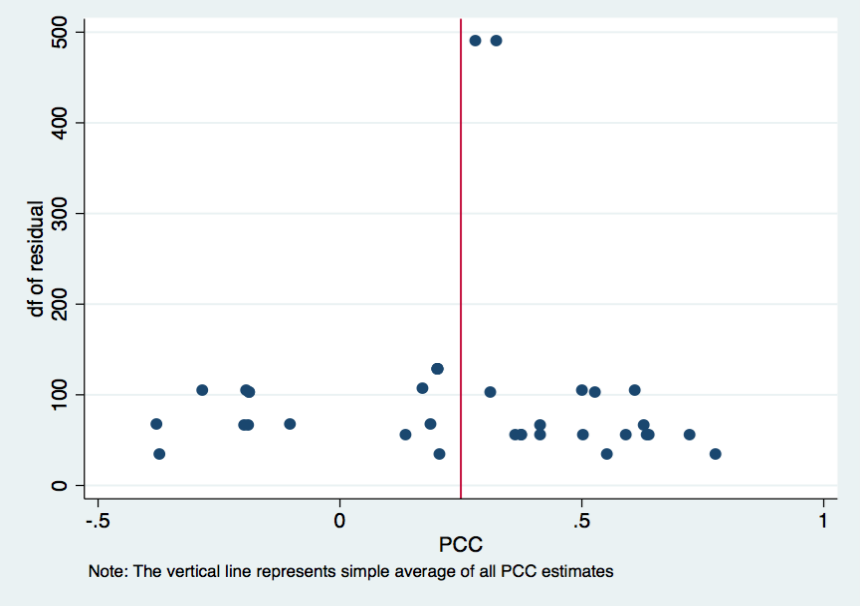

Figure 3. The funnel plot with degrees of freedom

To statistically assess the publication bias, we follow Balima et al. (2017). The model we utilize accounts for within-study dependence by the incorporation of random individual effect for each chosen study.

$$Effect_{ij} = \beta_1 + \beta_0 SE_{ij} + e_i + \lambda_j \quad (5)$$

where *Effect* corresponds to estimates value, *SE* is the standard error, *e* and λ reflect estimate and study level disturbance terms, respectively. β_1 reflects the true effect of the key policy rate on interest rate and $\beta_0 SE$ captures 'the noise' or authors intend to prefer statistically significant results. By dividing equation (5) by *SE* we correct for heteroscedasticity, which is presented due to differences among studies:

$$t_{ij} = \beta_0 + \beta_1 \left(1/_{SE_{ij}}\right) + e_i + \lambda_j \quad (6)$$

where t corresponds to collected t-values. Then we check the presence of Type I publication bias by testing the null hypothesis that the intercept in equation (6) is equal to zero. If the intercept is statistically significant, it means that the collected estimates do not vary symmetrically and randomly around the 'true effect'.

Since we have estimates with opposite signs, we replace the left part of the equation (6) by absolute value of t-values and this give us:

$$|t_{ij}| = \beta_0 + \beta_1 \left(1/_{SE_{ij}}\right) + e_i + \lambda_j \quad (7)$$

Testing the null hypothesis $\beta_0=0$ in equation (7) allows us to check the presence of Type II publication bias.

Table 3. Test of the true effect and Type I publication bias, equation (6)

1/SE pcc (Effect)	0.479 **
Constant (Type I Bias)	-2.613
Observation	36
Studies	7

Notes: The response variable is the t-statistic of the estimated coefficient on key policy rate. Estimated using the mixed-effects multilevel model.
** denotes significance at the 10%, ** – at the 5%, *** – at the 1% level.*

Table 4. Test of the true effect and Type II publication bias, equation (8)

1/SE pcc (Effect)	0,422 **
Constant (Type II Bias)	-1,215
Observation	36
Studies	7

Notes: The response variable is the module t-statistic of the estimated coefficient on key policy rate. Estimated using the mixed-effects multilevel model.
** denotes significance at the 10%, ** – at the 5%, *** – at the 1% level.*

Results of the meta-regression are presented in Tables 3 and 4. For both equations (6) and (7), the constant term is insignificant even at 10%, which means that the publication bias of neither type is present. The partial correlation coefficient is about 0.4 and significant. According to the scale by Doucouliagos (2011), the effect of key policy rate on lending rate is 'large'.

5. Conclusions

We analysed the literature, which investigates the effect of key policy rate on lending rate. Initially, we found 13 articles, but we rejected some of them since some included money market rate as the control variable or lacked estimates of standard errors. We ended up with 36 estimates from 7 papers. Based on average estimates of PCC, there is a positive, medium-size, significant effect of key policy rate on bank lending rate. When based on meta-regression analysis, the effect is positive, large and significant. Publication bias of either Type I or Type II is absent in our topic.

It is worth noting that the effect of the key policy rate on lending rates could be weaker due to the shape of the banking system in some economies. One reason is that banks' alternative costs in case of policy rate change may limit the transitional mechanism. For example, frequent changes of the key rate in the past may put banks into standby mode without an immediate response to the policy of the central bank.

The second reason is that the connection between the policy rate and lending rates may be weak in the case of inelastic demand for loans. Banks are in no hurry to change their lending rates since demand for loans changes less than the change in the rate of loans.

Ukraine, which on average has higher than a 50% non-performing loans ratio, serves as an example of the third reason. Banks might pay more attention to serving existing portfolios and not grant many new loans to economic agents. Therefore, the key policy rate may have no or only a limited effect on lending rates in

Ukraine. Our suggestion for further research is to study interest rate pass-through separately in economies with weak banking systems. Such a meta-analysis might shed more light on how the situation should evolve in Ukraine.

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DETERMINANTS OF HOLDING INTERNATIONAL RESERVES: EVIDENCE FROM META-REGRESSION ANALYSIS

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ABSTRACT

Traditionally, gold and currency reserves are seen as one of the key elements in protecting the economy from external shocks and their accumulation is largely perceived as an insurance against the risk of these negative (in terms of the effect on the economy) shocks occurring. Optimization of reserves is of great economic importance, since their understatement worsens a country's solvency on the world market and limits the regulatory capabilities of the state while the opposite situation leads to the freezing of a significant part of the national wealth for a long period, which means missing the potential of its possible investment (opportunity cost) Our study tries to systemize existing evidence on the main determinants of international reserves and ascertain the significance of their effect.

Key words: international reserves, shocks, meta-regression analysis

JEL classifications: C12, C83, E58, F41

1. Introduction

In the light of the recent global financial crisis, both developed and developing economies have to take into account that growing financial integration makes open markets more exposed to capital flight and sudden-stop crises (Aizenman et al., 2015). After the 1990s financial crises, countries' behaviour in managing foreign reserves accumulation was characterized as 'hoarding'. This tendency evolved when it was revealed by contemporary studies that in the case of the Asian crisis, as Lane and Burke (2001) note, states with the largest reserves holdings were in fact the least affected by speculative pressures. This and related studies have led to a renewal of interest in the pattern of international reserves accumulation. This interest has trended

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for more than a decade now, with newer papers, such as the already mentioned work of Aizenman et al. (2015), trying to determine whether the latest international financial crisis of 2008 and the following structural changes in the global economy have changed the behaviour of current foreign reserves holdings. The change reflects the increase in money inflows to emerging markets for higher yields and subsequent dynamic capital controls employed by the latter.

Traditionally, gold and currency reserves are seen as one of the key elements in protecting the economy from external shocks and their accumulation is largely perceived as an insurance against the risk of these negative (in terms of the effect on the economy) shocks occurring. The Central Bank (CB) uses foreign reserves for various practical purposes. Particularly, if a significant amount of foreign exchange reserves is at the disposal of the Central Bank, it can neutralize the imbalance in the currency market and protect the exchange rate from large fluctuations, cover imports and pay off external debts in the case of a budget deficit without overuse of quantitative easing. The International Monetary Fund (IMF) has a practice of providing foreign currency loans under relaxed conditions specifically for filling up the reserves. At the same time, as Cheung and Ito (2007) indicate, the fundamental rationale for holding foreign reserves ranges from transaction demand to collateral asset argument and mercantilist behaviour.

Optimization of reserves is of great economic importance, since their understatement worsens a country's solvency on the world market and limits the regulatory capabilities of the state while the opposite situation leads to the freezing of a significant part of the national wealth for a long period, which means missing the potential of its possible investment (opportunity cost). In this case the line between reasonable insurance against possible risks and excess precautions must be drawn. At the same time, there is no universal rule for optimizing the amount and structure of foreign exchange reserves. It depends on the range of a country's economic conditions, financial and institutional characteristics and even certain country-specific features (which are assumed to capture the above-mentioned rationales for international reserves holdings). This is the reason why the actual volumes of optimal reserves holdings vary substantially in the context of individual countries, although the majority of existing papers identify a number of basic factors that should be able to explain the significant part of variability in international reserves. Yet, another important issue still remains: how the determinants of foreign reserve holding, the scale of their effect and the optimal level of reserves, respectively, change over time. Our study tries to systemize existing evidence on the main determinants of international reserves and ascertain the significance of their effect. Most studies we worked through employed such factors as output variables such as gross domestic product (GDP), import (absolute or relative to GDP), export or export growth, a country's debt burden (absolute or relative to GDP), estimates of opportunity cost of reserves holding, inflation, money supply and others.

In our study, we focused on two of the most often employed determinants, which are imports and debt for the most part because the incidence of their use allowed for a statistically adequate meta-analysis. It should be noted that the effect of these two factors is by no means patent. When speaking of import, the intuition is that as imports grow, the vulnerability of current account grows (unless exports grow at a greater rate), which gives the CB incentive to hold more reserves. Thus, we should expect a positive sign of the corresponding regression coefficient because of the precautionary motive that we spoke of before. Yet a

range of studies (including Chowdhury et al., 2014 and Fatum and Hui, 2016) show that the coefficient by this component of current account is negative and insignificant when controlling for other determinants. As for the effect of debt on international reserves, there are several possibilities for explaining the relation between the two: 1) debt may serve as a substitute for reserves and therefore the relation should be negative; 2) reserves may be used as a collateral in raising debt from international donors and the sign of the corresponding coefficient would be positive; 3) the level of reserves may reflect the attempts to stabilize the external debt market, so here the precautionary motive is used once again to explain why, with an increase in debt, we should expect an increase in reserves. The arguments above illustrate why the direction of the effect of the variables of interest is not clear.

Another variable that is widely used for explaining reserves holdings is exchange rate, and its effect on reserves accumulation is ambiguous as is the case with the variables considered above. On the one hand, there is a similar intuition behind expecting a higher level of reserves with higher exchange rate volatility as in the previous case, while on the other hand, in the case of a prolonged strengthening of domestic currency against the dollar/euro we should expect a decline in the level of foreign reserves. However, if the currency appreciation was driven by a sudden increase in capital flows (due to an unexpected extreme rise in interest rates) the CB will anticipate capital outflows, which will lead to growth of reserves. Nevertheless, after studying the articles on the issue in question, we found that different authors used a different ratio for the exchange (dollar or euro for domestic currencies and the reverse relation) and many did not state this explicitly, so it is extremely difficult to define the sign of the coefficient for calculating partial correlations. In addition, when trying to separate articles that used the same measure of the exchange rate we obtained a small number of observations.

2. Literature review

Numerous studies have tried to unravel the determinants of international reserves holdings and their relevance. The studies we considered in our literature review can be divided into two categories: those that perform cross-sectional analysis with data for different countries over one or several periods, and those that use time-series analysis for one or more countries. Thus, econometric methodologies used in the studies ranged from simple OLS to autoregressive models, i.e. VAR and VEC. As the dependent variable, researches used international foreign exchange reserves, with some subtracting gold and/or adjusting for GDP (additionally, a significant number of papers used logged values for both explanatory and dependent variables, which is typical when working with macroeconomic variables in absolute terms). Samples vary according to time and number of countries considered. The majority of studies subject to the main determinants of the international reserves' demand reveal that it could be expressed as a relatively stable function of a few variables.

Interest in the patterns of international reserves accumulation firstly arose almost half a century ago with both Heller (1966) and Kelly (1970) exploring the potential impact of the USA predilection to import on the international reserves level. That gave a strong incentive to researchers to explore the influence of the main

macroeconomic aggregates on the explained variable. Starting in the early 2000s, the fundamental paper of Aizenman and Lee (2005) presented a precautionary demand for international reserves as a self-insurance against the risks of output and capital flight shocks in the case when the costs of terminating long-term projects are high. Moreover, if the economy is largely integrated in the world financial system, this may lead to a drastic reduction in deposits, and the authors emphasize that optimal managing of international reserves is of great importance.

Cheung (2007) in his work considered three groups of the determinants of international reserves. They are macro indicators (population, propensity to import, reserve volatility and opportunity cost of holding international reserves), financial indicators (M2, net debt to GDP ratio etc.) and institutional indicators (corruption, bureaucratic quality and so on). The relationship between international reserves and net debt to GDP is positive and its coefficient varies from 0.11 to 0.47, depending on time and whether the economy is developed or developing.

Kashif and Sridharan (2017) indicated that the main determinants of foreign exchange reserves are GDP, the real effective exchange rate and the money market rate. In their model, authors included economic size of the country proxied as real GDP, and trade openness captured by the sum of exports and imports of goods and services relative to GDP. The data were taken from IMF's International Financial Statistics and World Development Indicators of World Bank for the years 1984–2014. The estimations made using a vector autoregressive model showed that both factors are positively correlated with the dependent variable (international reserves). The authors concluded that a bigger impact of trade openness on foreign exchange reserves corresponded to the magnification of the influence of self-insurance motive.

Plenty of research considered the international reserves as a buffer stock (possibility of import coverage). Specifically, the literature confirmed the forecasts of the buffer stock model, which stated that international reserves had a negative relationship with the opportunity costs of reserves and exchange rate flexibility, but they are positively influenced by GDP, adjustment costs and reserve volatility. The last one is induced by international trade fluctuations, as shown in Aizenman and Genberg (2012).

On the whole, during the process of the literature search we looked for empirical researches where factors of demand for international reserves were analysed. In order to calculate the pooled effect on international reserves holding we selected empirical works where authors investigated different countries. The majority of the studies are devoted to the analysis of international reserves of Asian and Latin American countries. However, a number of papers used aggregated data for different nations and time frames.

3. Data

In order to conduct the meta-analysis of papers in our topic we searched for related studies in such sources as Google Scholar, SSRN, NBER and others. In the first stages of our search we came across 44 articles that were potentially suitable for conducting our analysis. After excluding studies without the necessary information (t-statistics, standard errors, degrees of freedom and number of observations), there remained 29 studies with variables of interest, where the dependent variable is international reserves and

independent variables are import and national debt. As for the latter, it is worth mentioning that while some articles used total debt (absolute or relative to GDP), others focused on indicators related to external debt. We decided to leave both and treat them similarly, as this approach does not violate our expectations that were considered in the introduction. Most of the factors were scaled by GDP and/or were in logs.

The common model for estimating holding international reserves is the following:

$$IR_i = \bar{\beta}X + \varepsilon_i \quad (1)$$

where *IR* is international reserves; *X* is the matrix of regressors that may include imports, debt (total or external), money supply, inflation and other; ; $\bar{\beta}$ is the vector of coefficients.

Depending on data samples and authors' assumptions, various estimation approaches were used, in particular simple OLS, fixed effects model (FE), vector autoregressive model (VAR), vector error correction model (VEC), autoregressive conditional heteroscedasticity (ARCH), autoregressive distributed lag model (ARDL).

From the list of studies that our meta-analysis is built on, we extracted 180 values of beta for imports and 35 values for various characteristics of debt. The majority of articles use transformations, such as logged values, or account for size of the economy by dividing each indicator by GDP. In both cases, more than 60% of betas are significant; as for the direction of the effect, for imports 142 coefficients are positive while for debt most have negative signs (only 8 are positive). As we have mentioned, at the initial stage, we excluded certain articles based on the absence of both degrees of freedom and number of observations. It is worth noting that some articles provided more models than others, and therefore we used more information from them compared to other sources. In this context, for imports we should mention such articles as 'A cross-country empirical analysis of international reserves' (Cheung and Ito, 2007) and 'Analysis of foreign reserves in the Arab countries, 1980–2002' (Bolbol and Fatheldin, 2005).

4. Methodology Outline

At first, after obtaining all estimates we obtained partial correlation coefficient for our variables with the following formula:

$$PCCij = \frac{tij}{\sqrt{tij + dfij}} \quad (2)$$

where PCCij is the partial correlation coefficient, tij and dfij are t-statistics and degrees of freedom, respectively.

Since we needed the normal distribution of PCC estimates, we then normalized PCC values by applying Fisher z-transformation (Fisher, 1921), which is used in a plenty of studies (for instance, Stanley and Doucouliagos, 2012):

$$Zpcc = 0.5ln(\frac{1+PCCij}{1-PCCij}) \quad (3)$$

Then, we obtained general PCC of estimates using simple average, fixed effect (FE) average and random (RE) effect average. The difference between these approaches is in weights (Borenstein, 2007). In the FE approach we weight estimates of PCC by the inverse of its variance, while in RE the estimates are weighted by the inverse of the sum of variance between study estimates and within study estimates.

To gain PCC indicators, we applied the following weights of fixed (Wfe) and random (Wre) effects as in Hedges et al. (2009).

$$Wfe_i = \frac{1}{\sigma i^2} \quad (4)$$

$$Wre_i = \frac{1}{\sigma i^2 + \tau^2} \quad (5)$$

where σi^2 is within variance of PCC,

τ^2 is between study variance of PCC.

It should be noted that the FE approach is conducted under the assumption that all studies were done with the same sample and number of observations, which means that we have only one sample error. This method does not show us correct estimates, since as it was mentioned above, we have rather more different data sets in analyzed studies.

The more succinct estimates of PCC are demonstrated by the RE approach, where we take into account different characteristics of samples to decompose the variance into within-studies and between-studies, and then apply these two values when weighting.

5. Publication bias (Type I and Type II errors)

Since meta-analysis is based on examining actual publications, a problem known as 'publication bias' can occur. In general, this is a bias that happens when results of certain research affect whether it is going to be published or not. In other words, there is a tendency to 1) print articles that are in line with commonly accepted position on the issue and 2) print papers with significant results while insignificant outcomes are neglected (Rothstein, 2005), that is there is some imbalance between studies (Song et al., 2010).

In order to estimate the publication bias of both Type I and Type II, we used a graphical method, which involves drawing a funnel plot, and an analytical method, which involves running regression of partial correlation coefficient (and its absolute value) on its standard errors by simple OLS and then running the same OLS but weighted to account for heteroscedasticity. The insignificance of the intercept in this regression means the presence of publication bias.

The funnel plot is a commonly applied tool to identify publication bias. In our analysis, we plotted PCC on the x-axis and on the y-axis inverses of its variances to define publication bias of Type I, and the precision estimate (1/SE) on the x-axis, with statistical significance (t-value) on the y-axis, to define publication bias

of Type II (Galbraith plot). When speaking of publication bias Type I, it can be assumed to be present if scatters are symmetrically distributed around the true effect. As for publication bias Type II, we can conclude that it is present when reported measures do not vary randomly around zero and the percentage of them corresponding to the confidence level do not seem to be within the respective range in terms of t-distribution.

6. Results and Discussion

6.1. Import

The average of all PCC_ij gives the simple mean partial correlation coefficient being equal to 0.22388 with 95% confidence interval [-0.485; 0.932]. Yet it is widely acknowledged that this partial correlation coefficient tends to have certain drawbacks concerning estimation precision of each β and the size of the corresponding sample. The second issue is connected to the possible bias of average effect due to the publication selection, which as was mentioned earlier, gives rise to Type I and Type II errors. That is why using the methodology above we have computed the fixed and random effects estimations, which nullify the described shortcomings. The value of a fixed-effect average PCC is (0.205547) with the 95% confidence interval [0.197; 0.214], which is a rather tangible difference with the random-effect PCC estimation, which equals 0.22894, lies in the [0.174; 0.283] interval with 95% probability. This is mainly due to the assumption of the same sample in all studies for the fixed-effect model, while the random-effect model relaxes this assumption. Further, we are going to concentrate on the heterogeneity of the influence of import in the reserves amount, using meta-regression. This all is summarized in Table 1 below.

Table 1. Estimation results for imports PCC

Variable	Average	Confidence interval
Simple average PCC	0.2238883	(-0.485; 0.932)
Fixed-effects average PCC	0.205547	(0.197; 0.214)
Random-effects average PCC	0.2289497	(0.174; 0.283)

In order to further explore the concept of publication bias, we first use the funnel plot, where the PCC (effect in particular model) is on the horizontal axis and the accuracy of the effect is on the vertical axis. To observe the absence of publication bias for the import effect in the variety of studies, the plot should resemble an asymmetrical funnel.

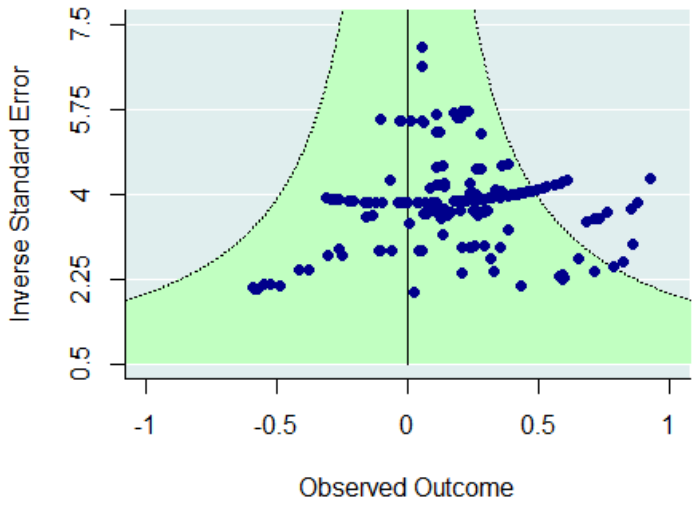

Figure 1. Funnel plot for the publication bias for import effect

From this informal test, we could conclude that researchers may be inclined to report a positive effect of the import on holding international reserves. Furthermore, we substantiate the obtained results by formal test using the methodology of Stanley and Doucouliagos (2010). We regress the PCC_ij on the standard deviation from the corresponding study, which in this case indicates exactly the publication bias:

$$PCCij = \beta 0 + \beta 1 SEpccij + \mu i;\ j = 1,\ldots, N;\ i = 1,\ldots, S \quad (6)$$

If coefficient $\beta 1$ is not statistically significant, the publication bias is not present.

In fact, it can be shown that equation (6) is heteroscedastic, therefore it is appropriate to use weighted least squares. Equation (6) is transformed to:

$$\frac{PCC_{ij}}{SE_{pccij}} = \beta_0 * \frac{1}{SE_{pccij}} + \beta_1 + \mu_{ij} * \frac{1}{SE_{pccij}} = \beta_1 + \beta_0 * \frac{1}{SE_{pccij}} + v_{ij} \quad (7)$$

With these modifications to the model and using our data, we obtain the following coefficients (the corresponding p-values are given in brackets):

$$\frac{PCC_{ij}}{SE_{pccij}} = t = -0.31 + 0.22 * \frac{1}{SE_{pccij}} + v_{ij} \quad (8)$$

(0.57) (0.00)

The values of t-statistics and corresponding p-values indicate that the β_1 is insignificant while β_0 is statistically significant even with 99% confidence. Thus, in terms of statistics, we have proof that there is no

publication bias for the results that report the influence of imports on international reserves holdings. We also can observe the existence of the effect of imports, which is positive. This supports the intuition that the central banks increase reserves in order to protect financial stability from external shocks, which may have a larger impact for countries with a higher propensity to import.

To check the Type II publication bias we used the methodology used by Tokunaga and Masahiro (2014). We regress the absolute value of the *t* value of the *j*-th estimate on the inverse of the standard error and obtain the following regression:

$$\text{abs}(tj) = \beta 0 + \beta 1(1/SEj) + \mu i; \quad j = 1,\ldots, N; \quad (9)$$

And obtain the next results:

$$\text{abs}(tj) = -9.66 + 0.23772\ (1/SEj) + \mu j \quad (10)$$
$$(4.01^{*})(0.021^{***})$$

The intercept term is significantly different from 0, indicating the presence of Type II publication bias. We also incorporate the graphical verification of the presence of Type II bias:

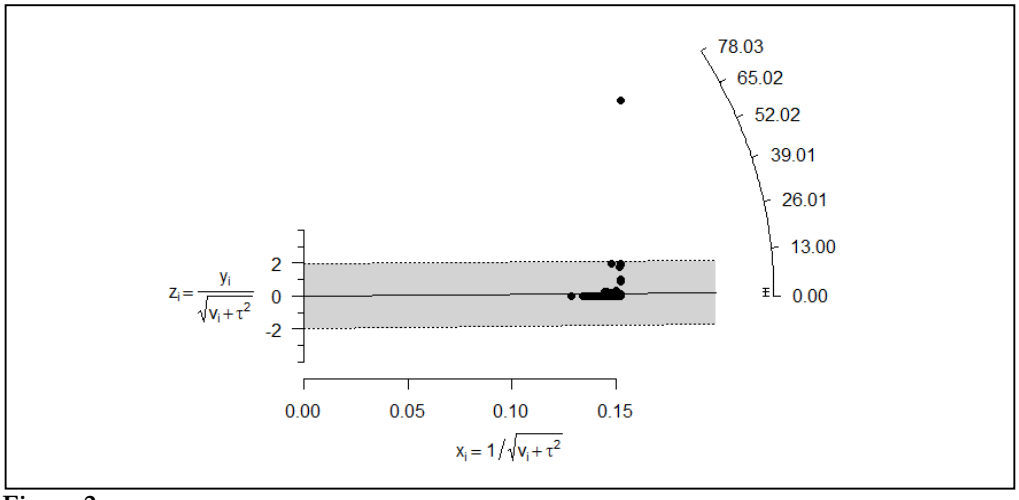

Figure 2

6.2. National debt

When investigating the effect of national debt on foreign reserves holdings we go through the same analysis procedure. The obtained results for simple PPC, fixed-effect PCC and random-effect PCC are presented in Table2.

Table 2. Estimation results for debt partial correlation coefficient (PCC)

Variable	Average	Confidence interval
Simple average PCC	-0.1607342	(-0.709; 0.388)
Fixed-effects average PCC	-0.1619223	(-0.186; -0.138)
Random-effects average PCC	-0.1618308	(-0.261; -0.062)

The funnel plot for testing the publication bias indicates that it could be present, but the formal test refutes its assumptions. From equation (10) it is clear, that bias is absent.

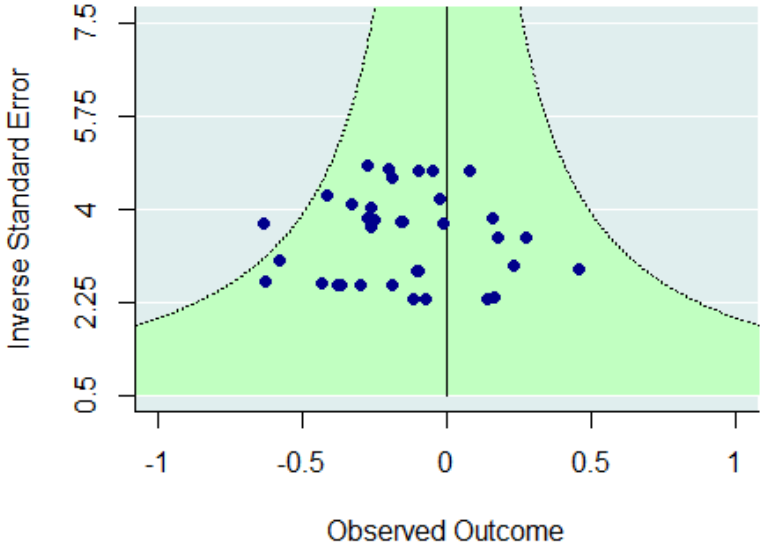

Figure 3. Funnel plot for the publication bias for national debt effect

Then we applied regression analysis as in the previous case to find if there is a publication bias and a true effect for national debt (p-values once again in brackets):

$$\frac{PCC_{ij}}{SE_{pccij}} = t = \underset{(0.087)}{0.163} - \underset{(0.07)}{0.165} * \frac{1}{SE_{pccij}} + v_{ij} \quad (11)$$

For this adjusted for heteroscedasticity model, once again we have obtained that there is no publication bias as for the effect of debt on the level of foreign reserves held in the country, which is negative. This in turn gives evidence that national debt may in fact be considered by the central banks as a substitute for international reserves.

The same approach is used to test for the Type II publication bias for the research papers, where the

national debt appears. The regression results are the following:

$$\text{abs}(tj) = 2.48 + 0.014\,(1/SEj) + \mu j \quad (12)$$
$$(0.38***) \quad (0.006***)$$

Again, the intercept term is statistically different from 0, indicating Type II publication bias. The Galbraith plot is shown in the graph below:

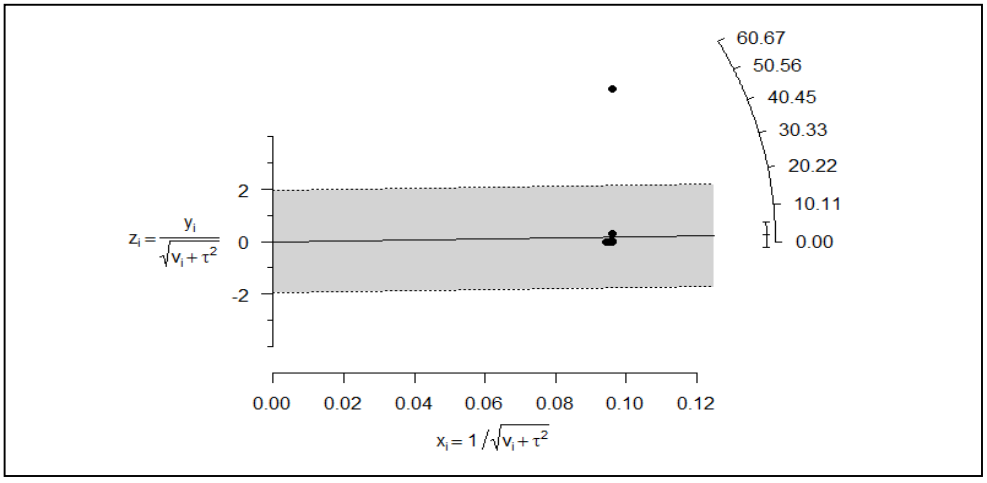

Figure 4

7. Conclusions

In our report we tried to systemize results of existing empirical research on the factors that affect holdings of international reserves. While the literature uses various variables to explain the changes in the level of foreign reserves holdings, we focused on two, namely imports (or propensity to import as Import/GDP ratio) and debt (or Debt/GDP).

We found that for both imports and national debt there is a true effect while no publication bias is observable, as shown by weighted OLS. What our meta-analysis has discovered is in fact quite remarkable. With our small research we found evidence that first, reserves seem to be held for precautionary motives, as with the rise in import and the related increase in the economy's vulnerability to external factors central banks tend to hoard reserves. Second, our results support the theory that debt is more of a substitute than a complement to a country's international reserves. The latter conclusion, however, may be notably strengthened by conducting a different analysis for countries with a different position in terms of international trade (for example, oil exporters and oil importers, or keeping just the articles that control for exports or, ideally, current account).

There may, however, exist problems with the conclusions drawn from this meta-analysis due to the following reasons:

1. Different model specifications were used for calculating the coefficients for the variables in question.

2. The effect of some models on the average PPC is augmented by the number of models in different papers; this means that if researchers used specific methodology and built several models with only small modifications, the effect of the results of this research on final PPC would be larger than that of the paper with only one model.

3. The effect of debt and imports on the pattern of reserves holdings should vary across countries and time. If more research was conducted on data from the same country, our estimation of partial correlation may be biased.

4. Some models may suffer from missing variable bias and heterogeneity across countries' economic development.

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META-ANALYSIS: EFFECT OF FX INTERVENTIONS ON THE EXCHANGE RATE

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ABSTRACT

Today foreign exchange interventions (FXI) remain one the most relevant and widely used policy tool for most Central Banks. The research is aimed at assessing the short-run effect of Central bank foreign exchange market interventions on nominal exchange rate level and volatility. The investigation is conducted in a form of meta-analysis and based on estimates for 8 countries, extracted from 12 studies with a common monetary policy regime. The research suggests that there is no consensus in the literature about the underlying issue. Utilizing a random effects model, we have found that according to employed studies that Central Bank's FX interventions (USD sold) in the short run lead to local currency appreciation while increasing market volatility. However, these effects are close to zero. The validity of the results has been examined for publication bias by utilizing formal techniques.

Key words: foreign exchange interventions, exchange rate, monetary policy, meta-analysis
JEL classifications: C12, C83, E58, F31

1. Introduction

Since 2016 Ukraine has shifted to inflation targeting regime in conducting monetary policy with managed floating exchange rate. However, being a small open economy Ukraine is considered to be impacted by exchange rate shifts, which usually tend to be translated onto domestic price level and impacting targeted indicators. In such conditions, Ukraine monetary policy authority pays specific attention to choosing an appropriate instrument to stabilize the exchange rate. Today foreign exchange interventions (FXI) remain the most relevant and widely used policy tool for most Central Banks. While some recent studies claim that interventions may help to enhance welfare (Gabaix and Maggiori, 2015), there is a range of studies that doubt

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their effectiveness. Hence, assessing the magnitude and timing effect of one of the most popular Central bank instruments - foreign currency exchange market interventions - arises with severe importance.

This meta-analysis examines various FXI practices and its effects on exchange rate movements. We would like to investigate the possible effect both on the level and volatility of the exchange rate. For the analysis, we take into considerations those studies who research the cases similar to Ukraine, in particular, with sterilized interventions and floating exchange rate regime. As long as we only consider the papers with daily data frequency, this paper provides the evidence for short-run effects.

While many studies claim that actual interventions are often insignificant in their impact on exchange rate dynamics (if we consider their sizes), there is a theory which provokes the signaling function of the interventions. It states that the interventions may arise as an important signal for foreign exchange market participants. Therefore, our analysis of the impact of interventions separately compares the quantified amounts of interventions and the fact of interventions as a Central Bank's signal with the exchange rate fluctuations.

This study may help the National Bank of Ukraine define the objective of FXI and provides evidence of the effectiveness of this policy tool as a currency stabilizer.

The paper is constructed as follows. In section 2, we review the previous literature on the FXI effects on exchange rate dynamics. We continue in section 3 describing the articles used for the meta-regression analysis, the assumptions made to develop single criteria for further research, and the models used in chosen papers. In section 3 we present the methodology of our meta-analysis. There, we describe two approaches to weighing different studies.

2. Literature review

Meta-analysis is a research that is based on the previous investigations on the topic and targeted onto finding the consensus view on the research question.

In total 69 articles have been chosen for analysis, whereas only 12 of them have been utilized for the eventual meta-analysis after considering special attributes due to the possibility of the future comparison and summation of the studies' results. The reasons for excluding articles from the analysis were: absence of well-designed results (theoretical papers, including simulations); inapplicability of the result in meta-analysis due to the model specifics and/or dependent/independent variables under study, that couldn't be translated into unified form; low quality of paper and countries' specific factors.

Meta-analysis requires an article with a strong empirical base and results to put them into the model. However, there are some mainly theoretical papers under study in order to understand the idea behind interventions better. In "The foreign exchange market interventions of the European Central Bank"(2012) by M.Frenkel, C.Pierdzioch, G.Stadtmann there are many issues about interventions were observed, but one of the most important is sterilization. There are some measures, taken to neutralize expansionary or contractionary effects, but neutralization doesn't mean an absence of the effect at all and the article gives a flavour of these effects. It's an important topic because there are sterilized interventions mostly used

throughout dozens of articles under investigation in the meta-analysis paper.

A very important factor, which influences the effect of FX interventions a lot (as long as the quality of the data and other minor factors), is a type of economy. An answer to this question could change things dramatically due to the difference in the problem set, that are facing a National Banks and society at all. A huge amount of papers under investigation did the analysis for the Japan and Latin America countries. It seems rather reasonable to observe two papers that correspond to these two cases because Japan is a developed economy and Latin America countries are emerging economies. In the "Central bank intervention and exchange rate volatility" by Kathryn M. Dominguez (1998), there are research about G-3 (US, Germany, Japan) central banks activity and the result here claims that exchange rate volatility could be affected by the interventions, however there is a division on the effect of secret interventions and announced interventions which would be discussed in the next section. In the first case, there is no effect as much, as in the second case and it could be explained by an absolutely different mechanism of expectations built by the publicity, which is based on the level of credibility of the central bank. The level of credibility depends on the level of the economy and there is some causality effect, like it shown in a series of studies where "Central Bank Independence and Transparency: Evolution and Effectiveness"(2008) by C.Crowe and E.Meade is one of them. Another paper, that contains most of the information about credibility in the last decade papers, which become a popular topic in the last 90s, is a "Central Bank communication and monetary policy: a survey of theory and evidence"(2008) by A.Blinder et al. In another case, with emerging economy, Herman Kamil in his "Is Central Bank Intervention Effective Under Inflation Targeting Regimes? The Case of Colombia" (2008) have shown that in the emerging economies market faces many breaks and changes, very aggressive intervention strategy and many more which gives a higher effect than in the developed economies. It is like a difference between a modern subway and a roller coaster, but they must have been done correctly anyway.

The model to make a research affects the result much, thus it must be chosen wisely. As we had noticed, there is a tendency to use GARCH-type models to investigate an effect of interventions. It is a relatively natural choice because we have a daily (very short run) data and necessity to observe a volatility mostly. More structural or OLS-type models concentrated on the long-run trends, which is not the best way to use for a high-frequency data, however, there is also some long-run effects of the interventions and they have to be examined too. Thus, the model is chosen based on the object of the research and it is nice to overview some of the cases. As far as GARCH-type are the most popular models in this segment of papers, we will begin with them. "Are Capital Controls and Central Bank Intervention Effective?"(2010) by Hernan Rincon and Jorge Toro is a paper, which investigates an effectiveness of different policies for depreciating the exchange rate and reducing its volatility in Colombia. There are about 4.5 thousand observations and, in order to use this information, authors evaluated AR(1)-GARCH(1,1) model where the dependent variable is an exchange rate return and there are lags, interventions, and taxes among independent ones. But the other point of interest of authors is a volatility, which is modeled by a long equation with interventions, taxes, their relationship, spread, and different lags. So, these two equations are with a minor difference, but the resulting significance of the corresponding coefficient is not similar. In this case, authors estimated, that coefficient near to interventions is insignificant in the case of mean and very significant in the variance of return. It is a

great result because if they'd use regular OLS, it's quite possible to obtain an insignificance of interventions, while it is not the case in a reality (or, at least, with a GARCH approach) due to endogeneity issues. Another study in this sector is a "Does central bank interventions increase the volatility of foreign exchange rates?" (1993) by Kathryn M. Dominguez examined an intervention policy of Bundesbank and Bank of Japan in their intention to influence the level of exchange rate. There is an evidence of the high degree of volatility of the exchange rate in this period and it could be studied by an appropriate model, which is a GARCH in this case. Frankly speaking, it is one of the oldest papers in this meta-analysis and it is like the pioneer paper in the exploring of the exchange rate volatility. The GARCH was modeled in a manner to capture interventions in US, Germany, and Japan, daily and holiday dummies, news and secrecy dummies and their effect on the log of the spot exchange rate. The volatility was designed in the same manner, but it is capturing only different interventions and a news dummy. There are many results which are obtained from these model, but the important one is that there is a difference between the effect of the same interventions on the level and on the volatility, so as in the previous example. It is a very important finding which suggests about an importance of differentiating between level and volatility while studying exchange rate.

However, there is an absolutely different way to have a look at interventions and their effect. As would be shown in the next section it'd be examining long-run trends. The first example contains a very unusual Structural VAR model, which is used in order to have a look at the effect of an exogenous change in FX intervention via three structural shocks. It's described in the "Asymmetric effects of FX intervention using intraday data: evidence from Peru" (2013) paper by Erick Lahura and Marco Vega. In this model, it's necessary to put the long-run restrictions first (which is quite different to other studies in the very beginning because they examine short-run mostly), evaluate an SVAR and have a look on the results. For example, a positive exchange rate shock has a negative cumulative effect on dollar purchases and positive on sales which seems quite reasonable. This model doesn't contribute to the short-run understanding of the exchange rate as expected, according to the design. As well as the next example: DSGE model which is made to describe a Banco de la Republica FX intervention policy by H.Vargas, A.Gonzalez, and D.Rodriguez in their "Foreign exchange intervention in Colombia" (2013). In the best traditions of DSGE models, it contains about 30 different equations which give an opportunity to have a look over the different shocks influence on the economy under two different policies (aggressive and passive FX interventions policies). Interventions are modeled in the model in a way that deviation from the target of Real Exchange Rate leads to the corresponding intervention. And, at the very end of the section, it's nice to observe the simplest, but still, a very important method such as OLS using "The Effects of Japanese Foreign Exchange Market Interventions on the Yen/U.S. Dollar Exchange Rate Volatility" (2003) paper by M.Frenkel, C.Pierdzioch, G.Stadtmann. However, the appropriate use of such a technique could lead to the sensible result. Here the dependent variable is a logarithm of the ratio between the volatility of the exchange rate now and in the previous period, while the independent variables contain interventions and different other dummies and indexes. The result showed a significant effect of interventions on daily data, so this approach could be used as well, as the GARCH. So there are a great variety of models to observe interventions effect, which serves for different purposes which makes a wide field for the meta-analysis type research to evaluate results of different models

groups.

Another important difference between the papers is a dataset. They were built differently for corresponding purposes. For example, structural models rely more on daily/weekly/monthly data while those, which examine volatility, use a daily or different type of intra-day data. For example, M. Taylor used a simple daily data in his "Is official exchange rate intervention effective?"(2003) to deal with the effect of official interventions, so as in the paper "The effectiveness of Central Bank Intervention in the EMS. The Post 1993 Experience"(2001) by P.Brandner, H.Grech, H.Stix. The reasoning to doesn't use more sophisticated, intra-day, data is an absence of identification of what type of transaction it is and misinterpret it, which could lead to the great bias. However, in other works with modern data, this problem is solved and authors were able to use more data. For example, in the "Central Bank Intervention and Exchange Rate Volatility: Evidence from Japan Using Realized Volatility"(2013) by A.Cheng, K.Das and T.Shimatani they've used a 5-minutes frequency data for computing daily variance, in other words to aggregate the data into something meaningful. The 5-minutes data itself couldn't be so useful in terms of modeling the effect of interventions because it is coming with some lag (which is different for agents), but, as long as the working paper statements are correct, it varies in the 1 day interval (depends on the working hours of different markets where Yen is in use and the difference in GMT).

One issue that arises widely in the papers is the difference between secret and public interventions and their effect on the exchange rate. S.Kim and A.Le in their "Secrecy of Bank of Japan's Yen intervention: Evidence of efficacy from intra-daily data" arises this question as the main of the paper and built a special model to investigate the difference between effects. It's a GARCH model which contains special terms for the public, secret rumored and secret undetected interventions in its mean and volatility parts. The difference between corresponding coefficients and their sign was the most important part of a paper. But there are other interesting points, such as news and events dummies like in "On central bank interventions in the Mexican peso/dollar foreign exchange market"(2013) by S.Garciaa-Verdu and M.Zerecero. They've estimated models, with variously designed dummies because it has an effect in the very short run and could affect volatility much. It could be an announcement for some intervention from CB or news like a problem with some goods that are exported from the country and many more. In this research dummies of this type have a significant effect and must be included in the model, if the data gives this opportunity. And the last but not least is a different additional object to study, such as a series of interventions, their amount and many more. It's done, for example, in "The effectiveness of FX interventions in four Latin American countries" (2012) by C.Broto. Dummies, mentioned above, are included in both mean and volatility in the GARCH model and their effect is quite significant. The idea behind the first in the series works in a news dummy manner, which gives a flavor of what will happen in the market in the nearest future, in another word it's an expectations building.

Articles in this research are rich for a different approach, objects of investigation and different values that might be counted in the total effect of interventions on the level of exchange rate. However, in the new paper, everything must be chosen wisely, it must take into account the data availability, country specialty, and other factors.

3. Data description

We have started our analysis from 69 articles, arriving at the eventual 12 articles based on the following criteria:

- nominal exchange rate under study;
- floating exchange rate regime;
- sterilized interventions;
- daily data frequency.

Restricting the sample of the articles in the research was necessary to proceed with comparable estimates for concluding on consensus effect across the studies.

Observations for the meta-analysis were taken from econometric models that can be summarized to the following general form:

- GARCH model and its modification:

$$log\left(\frac{e_{it}}{e_{it-1}}\right) = \beta_0 + \beta_1 \cdot I_{it-1} + \beta_2 \cdot X_i + \varepsilon_t,$$
$$\varepsilon_t = \varepsilon` * \sqrt{h_t}$$
$$h_t = \gamma_0 + \gamma_1 \cdot I_{t-1} + \gamma_2 \cdot X_i + \gamma_3 \varepsilon_{t-1}^2 + \gamma_4 h_{t-1}$$

where e – exchange rate (return), I – FX intervention, X – a vector of control variables, i and t – country (in the articles with estimations on multiple countries) and time indicators, respectively, ε – error term, $\varepsilon`$ – gaussian and h – variance (volatility as fitted values).

- OLS model:

$$log\left(\frac{e_{it}}{e_{it-1}}\right) = \beta_0 + \beta_1 \cdot I_{it-1} + \beta_2 \cdot X_i + \varepsilon_t$$

where e – exchange rate (return or volatility), I – FX intervention, X – a vector of control variables, i and t – country (in the articles with estimations on multiple countries) and time indicators, respectively, ε – error term.

We have investigated the idea of the impact of Central Bank interventions separately on exchange rate level and volatility. The total amount of estimates was divided into 2 groups: the ones that access the quantitatively distinguished impact of interventions (amount of intervention was normalized to 100 mln USD) and the ones that represent the impact of the fact of FX interventions without specifying the amount of the currency injected to/extracted from the market. The following table summarizes the total number of estimates for each dependent variable and specifies the form in which the dependent variable entered the model it was extracted from:

Table 1. Summary on obtained estimates for analysis

Dependent variable	How enters the model	# of observations
Level	return on the exchange rate in logarithm	13
Volatility (amount)	the difference in standard deviation in logarithm volatility, extracted from the GARCH model implied volatility on derivative instruments	17
Volatility (fact)	the difference in standard deviation in logarithm volatility, extracted from the GARCH model	5
Total		**35**

In the analysis, we utilize estimates on the association between exchange rate and Central bank interventions in the 8 counties, represented below. They consist of developed and developing countries with floating exchange rate and predominantly inflation targeting regime:

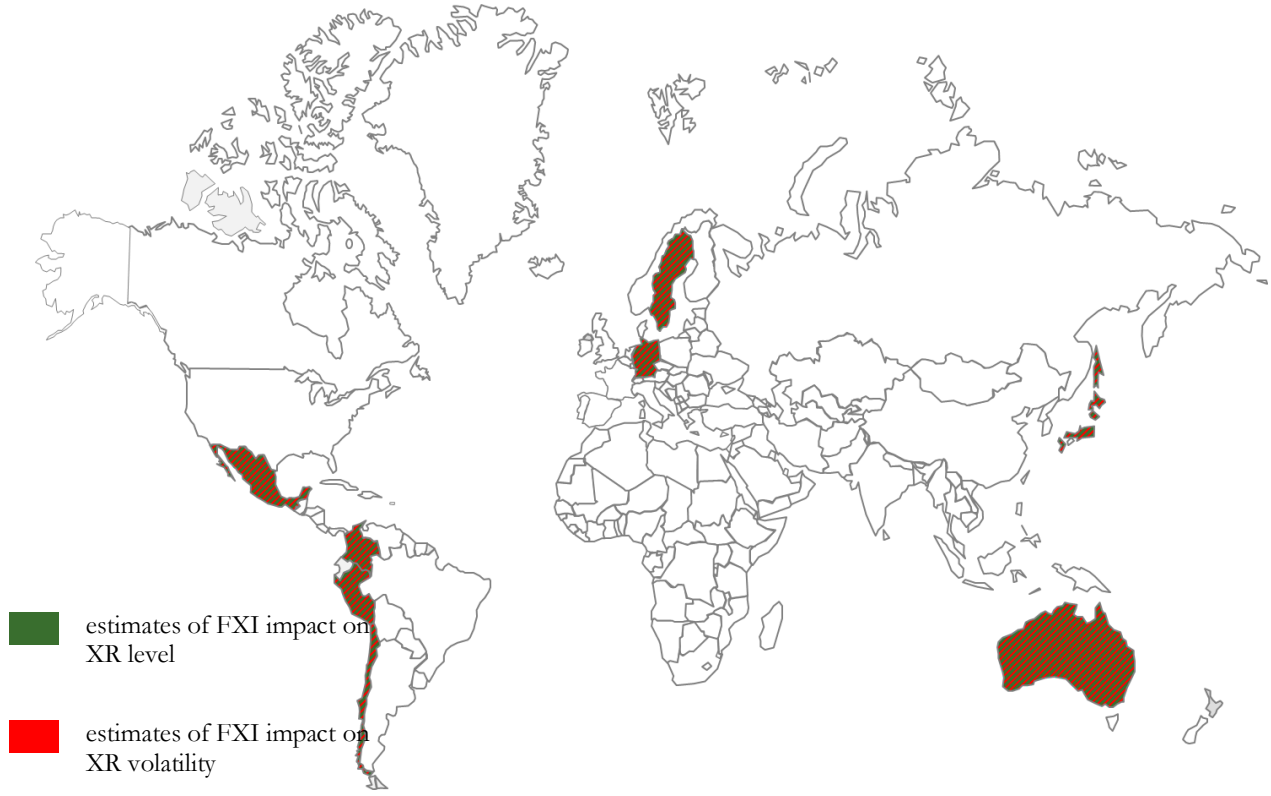

Figure 1. World map highlighting countries estimates for which used in the analysis

4. Methodology

Meta-analysis is a type of study that is targeted onto providing a consensus view on the research questions. There are two basic statistical models of performing meta-analysis: fixed-effects and random-

effects models. They substantially differ in methodology and respectively diverse results.

- *Fixed effects model:* usage of this model presumes that there exists one true parameter for all studies and estimating results vary only due to sampling error. In our estimation we used the inverse variance fixed effect model, which uses inverse variance for weighting coefficients, collected from studies. The drawback of this model is in assigning large weights for a couple of estimates, which does not appear to be a problem only if one true parameter is considered for all studies. Formally, eligibility for using this model may be assessed through I-squared. High coefficient shows that there is substantial heterogeneity across the extracted estimates' true parameters and using the fixed effect model is inappropriate.

Formal model for fixed effects:

$$\overline{ES} = \frac{\sum w_{FE} * ES}{\sum w_{FE}}, \; w_{FE} = \frac{1}{V_{ES}}$$

Where w_{FE} – weight assigned to the estimate, V_{ES} – variance of the estimate

- *Random effects model*: model implies different true parameter across the studies. According to Table 1 fixed effects model should not be used in the analysis due to large heterogeneity. This may be explained by the fact of collecting estimates from the variety of countries and time-periods with respective structurally different economic and monetary systems with local peculiarities.

Formal model for random effects:

$$\overline{ES} = \frac{\sum w_{RE} * ES}{\sum w_{RE}}, \; w_{RE} = \frac{1}{V_{ES} + \tau^2}$$

where w_{FE} - weight assigned to the estimate, V_{ES} – variance of the estimate, τ – random variable.

In the analysis, we have divided the estimates obtained into two sub-samples for the further analysis:

- models, where FX Interventions entered in the amount (coefficients on interventions were transformed as of 100 mln USD intervention);
- models, where FX Interventions entered as the fact (dummy variable – 1 on the day of intervention).

Hence, the first model would highlight the consensus on the impact of the specific amount of foreign currency injected/extracted in/from the market, whereas the second would show the impact of the fact of intervention – the presence of Central bank on the market.

4.1. Publication bias

Since meta-analysis is the type of study that highly depends on the methods and means of extraction the results on the previous studies, the analysis should be checked any sources of bias. The common practice in meta-analysis is to check for publication bias. It is assessed through the existence of a correlation between the size effect of estimate and its precision or sample size, used in the particular study. Publication bias arises

because of the tendency of publishing studies with some significant estimates of the results that coincide with mainstream theories. Publication bias is represented through a funnel plot, which consists of an estimate (partial correlation coefficient) on the x-axis and inverse standard deviation on the y-axis (Stanley et al, 2010). The symmetric funnel plot is an indication of no publication bias, whereas skewed funnel plot points to its existence. The existence of bias may be formally assessed through the Egger regression test, where normalized estimate regressed by its precision measure (Egger et al, 1997):

$$\frac{ES_i}{SE_i} = \beta_0 + \beta_1 \frac{1}{SE_i} + \varepsilon_i$$

In the case of insignificant betas, we claim no publication bias in the analysis.

5. Estimation results

Firstly, we assessed the effect of the specific amount of FX intervention on the exchange rate. Considering fixed effects model, the I-statistic has pointed onto large heterogeneity (of the true parameter) across the studies. Hence, consensus obtains on the basis of this model is not robust.

Table 2. Fixed effects model I-squared statistics

	I-squared	Fixed effect model
Level	99.80%	inappropriate
Volatility	99.90%	inappropriate

Source: authors' estimations

Random effects model estimation yields the following results:

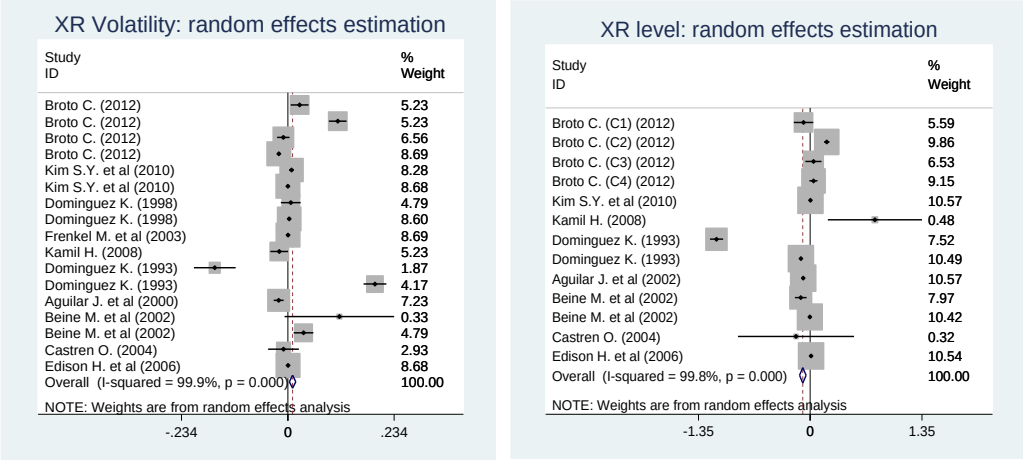

Figure 2, 3. Level (2) and volatility (3) random effects model

Source: authors' estimations

Across the analyzed studies there was no majority consensus on the sign of the effects as well as the magnitude. According to the random effect model estimates, consensus impact of 100 mln USD intervention (foreign currency sale) on local currency level was -0.1% (in period t+1), which may be treated as a neutral effect. However, results across the studies were very diverse, despite using common estimation techniques. For instance, Dominguez (1993) has found a significant negative effect of FX interventions on the exchange rate, with 100 mln intervention decreasing nominal exchange rate by more than 1.1%. On the contrary, Kamil (2008) estimated that the effect is positive and on average is 0.8%, but associated with relatively low significance.

The effect on volatility is even more cumbersome. On average each 100 mln USD intervention (absolute amount) increases volatility by 0.01%, which is close to zero and be neglected. One of the explanations, why FX interventions of Central Bank targeted onto volatility smoothing result in inverse effect – is that market participants receive a signal of worsened market conditions that necessitate treatment as CB enters the market, this adversely affects agents' expectations and increase uncertainty, as a result –volatility of exchange rate increases as well.

Table 3. Random effects model estimates

	Estimate	95% Confidence interval	
		Lower bound	Upper bound
Level	-0.089	-0.129	-0.048
Volatility	0.01	0.003	0.017

Source: authors' estimations

As the next step, the existence of publication bias should be examined. The following funnel plots represent the association between estimates (partial correlation coefficients) and the inverse standard deviation for the level and volatility estimates.

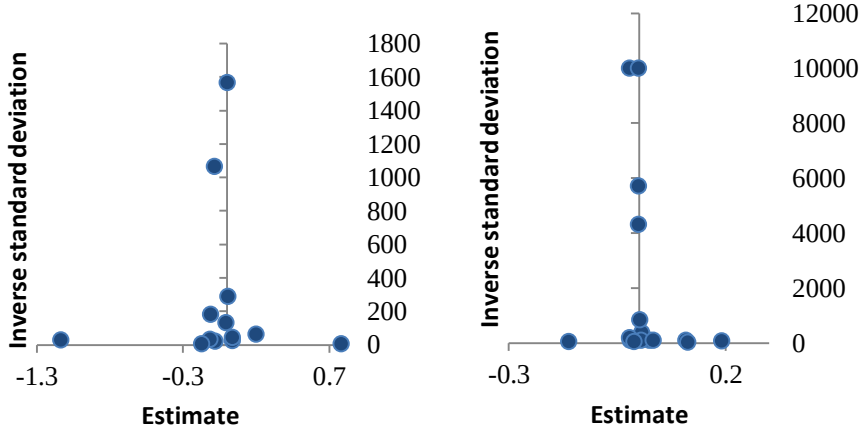

Figure 4,5. Level (4) and volatility (5) funnel plots
Source: authors' estimations

Whereas funnel plot for the impact of the intervention on the exchange rate level does not show the visual evidence of publication bias, the funnel plot for volatility appears to be slightly asymmetric – skewed to the right. However, it is worth mentioning that the publication bias is only one of the possible reasons for the skewed funnel plot (Sterne and Harbord, 2004). In case of high between-study heterogeneity (Table 1), the reason for skewed funnel plot may be indeed different true effect rather than publication or selection bias. Apart from the visual assessment of the existence of publication, we utilize the Egger regression test for both sets of estimates.

Table 4: Egger test results

	p-value	
	Constant (β0)	β1
Level	0.666	0.194
Volatility	0.493	0.781

Source: authors' estimations

According to Egger formal test, the regression coefficients are insignificant, that shows no evidence of publication bias in the analysis.

Our analysis consists of separate groups of estimates, the first one considers the impact of intervention depending on their amount on exchange rate level and volatility (highlighted above), whereas the second group assessed the fact on central bank's FX interventions on volatility.

Studies that investigated the impact of the fact of intervention on exchange rate volatility is scarcer. After employing the methodology that enables us to consider studies as comparable we arrive at 5 available estimates. I-statistic on the basis of fixed effects estimation if equal to 95%, that points onto large between-study heterogeneity and inappropriateness of utilizing fixed effects model.

Random effects model estimation yields the following results (including the previous results):

Table 5. Random effects model estimates

	Estimate	95% Confidence interval	
		Lower bound	Upper bound
Volatility	0.000	-0.012	0.013

Source: authors' estimations

According to the studies analyzed, we arrive at the neutral effect of the fact of intervention on the market volatility in consensus. Interestingly, K.Domingues studies – considering both amount and fact of intervention – show the significant positive effect of Central bank FX interventions. Whereas studies consensus is 0, the range of the estimates is quite wide, fluctuating from -0.015% to 0.317% impact on volatility including both estimates belonging to the same author, however different time frames.

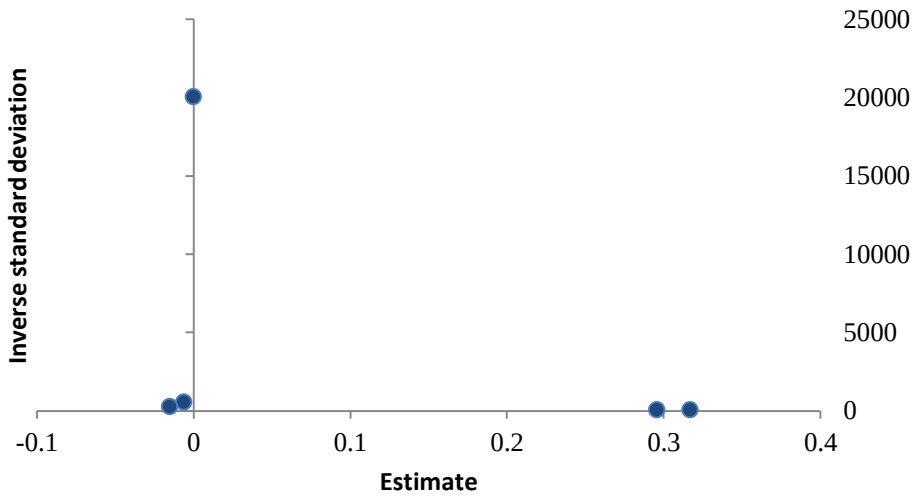

Figure 6. Level and volatility random effects model
Source: authors' estimations

6. Conclusions

The key research question of our meta-analysis is how does Central bank foreign exchange market interventions impact on nominal exchange rate level and volatility in the short run.

We have analyzed 12 articles about Central bank FX interventions in 8 countries (both – developing and developed) around the world with floating exchange rate (mostly IT regime).

According to our analysis, we may state that there is no general consensus in the literature about the sign and magnitude of impact on nominal exchange level. According to the random effect model estimates, because of 100 mln USD sale, local currency appreciates on average by 0.1%, which may be considered as neutral or no effect of the intervention on exchange rate level.

The effect on volatility is rather unexpected. On average each 100 mln USD intervention (absolute amount) increases volatility by 0.01%, which is close to zero and be neglected. One of the possible answers on why FX interventions of Central Bank targeted onto volatility smoothing result in inverse effect – is that market participants receive a signal of worse market conditions when Central Bank enters the market with FX interventions. This adversely affects agents' expectations and increase uncertainty, as a result – the volatility of the exchange rate increases as well.

Analysis of the fact of Central Bank intervention has yield also neutral result, though differing much across analyzed studies. Interestingly, K. Domingues studies – considering both amount and fact of intervention – show the significant positive effect of Central bank FX interventions. Whereas studies consensus is 0, the range of the estimates is quite wide, fluctuating from -0.015% to 0.317%.

Further analysis of the impact of Central Bank foreign currency market interventions on exchange rate may include:

• the analysis of central bank FX interventions on the exchange rate in the middle- and long-run;

• the differences of impact on the exchange rate between secret and publicly announced Central Bank's FX interventions.

Hence, there is no general consensus in the literature of Central Bank FX interventions on the exchange rate, albeit, estimations based on the random effects model yield in general neutral impact of interventions on exchange rate level and volatility in the short-run.

However, this topic could be quite useful for the Central Bank board as long as it is one of the main tools to affect the exchange rate and its volatility. There are a wide field of further investigation objects including the different effect of interventions secrecy, news and Central Bank openness, level of the economy under study (developed or emerging), other aspects that were observed during the articles mining. Different models for facets of interventions could help to decide whether or not the strategy and a view about them should be changed. So this meta-analysis is a significant basis for further research in this area.

Appendix A

Table 6. Aggregated data used for meta-analysis

Dependent	Estimate (PCC)	Standard error	Inverse standard error	Author	Year	Country
			Amount			
level	-0.08	0.06	16.67	Broto C. (C1)	2012	Chile
level	0.20	0.02	58.82	Broto C. (C2)	2012	Colombia
level	0.04	0.05	20.00	Broto C. (C3)	2012	Mexico
level	0.04	0.03	40.00	Broto C. (C4)	2012	Peru
level	0.00	0.00	1564.95	Kim S.Y. et al	2010	Japan
level	0.78	0.29	3.45	Kamil H.	2008	Colombia
level	-1.13	0.04	24.69	Dominguez K.	1993	Germany
level	-0.11	0.01	178.57	Dominguez K.	1993	Japan
level	-0.08	0.00	1062.70	Aguilar J. et al	2002	Sweden
level	-0.11	0.04	27.56	Beine M. et al	2002	German
level	0.00	0.01	129.79	Beine M. et al	2002	Japan
level	-0.17	0.36	2.80	Castren O.	2004	Japan
level	0.01	0.00	285.71	Edison H. et al	2006	Australia
volatility	0.03	0.01	100.00	Broto C.	2012	Chile
volatility	0.11	0.01	100.00	Broto C.	2012	Colombia
volatility	-0.01	0.01	142.86	Broto C.	2012	Mexico
volatility	-0.02	0.00	10000.00	Broto C.	2012	Peru
volatility	0.01	0.00	368.19	Kim S.Y. et al	2010	Japan
volatility	0.00	0.00	4310.34	Kim S.Y. et al	2010	Japan
volatility	0.01	0.01	90.09	Dominguez K.	1998	Germany
volatility	0.00	0.00	833.33	Dominguez K.	1998	Japan
volatility	0.00	0.00	10000.00	Frenkel M. et al	2003	Japan
volatility	-0.02	0.01	100.00	Kamil H.	2008	Colombia

volatility	-0.16	0.02	42.55	Dominguez K.	1993	German
volatility	0.19	0.01	78.13	Dominguez K.	1993	Japan
volatility	-0.02	0.01	180.83	Aguilar J. et al	2000	Sweden
volatility	0.11	0.06	16.22	Beine M. et al	2002	Germany
volatility	0.03	0.01	90.15	Beine M. et al	2002	Japan
volatility	-0.01	0.02	58.00	Castren O.	2004	Japan
volatility	0.00	0.00	5714.29	Edison H. et al	2006	Australia
			Fact			
volatility	0.30	0.07	15.16	Dominguez K.	Working paper	Germany
volatility	0.32	0.05	18.77	Dominguez K.	Working paper	Japan
volatility	-0.01	0.00	512.82	Garcia-Verdu S.	2014	Mexico
volatility	0.00	0.00	20000.00	Garcia-Verdu S.	2014	Peru
volatility	-0.02	0.00	250.00	Dominguez K.	1998	Germany

Appendix B

Table 7. Articles' description

Paper	Country	Period	Model	Perceived/ Official
Broto, C."The Effectiveness of FX Interventions in Four Latin American Countries" (2012)	Chile, Colombia, Mexico, Peru	1996 - 2011	GARCH	Perceived
Suk-Joong Kim; Anh Tu Le. "Secrecy of Bank of Japan's Yen intervention: Evidence of efficacy from intra-daily data" (2010)	Japan	1991 - 2004	AR-EGARCH	Official
Dominguez, K. "Central bank intervention and exchange rate volatility" (1998)	US, Germany, Japan	1977 - 1994	GARCH	Official
Frenkel, M.; Pierdzioch, C.; Stadtmann, G. "The Effects of Japanese Foreign Exchange Market Interventions on the Yen/U.S. Dollar Exchange Rate Volatility" (2003)	Japan	1993 - 2000	OLS (AR)	Official
Kamil, H. "Is Central Bank Intervention Effective Under Inflation Targeting Regimes? The Case of Colombia" (2008)	Colombia	2004 - 2006; 2007	2SLS, Tobit, GARCH	Official
Dominguez, K. "Does Central Bank intervention increase the volatility of foreign exchange rates?" (1993)	US, Germany, Japan	1985 - 1991	GARCH	Perceived
Aguilar, J.; Nydahl, S. "Central bank intervention and exchange rates: the case of Sweden." (2000)	Sweden	1993 - 1996	OLS, GARCH-M, SUR	Official
Beine, M.; Benassy-Quere, A.; Lecourt, C."Central bank intervention and foreign exchange rates: new evidence from FIGARCH estimations" (2002)	Germany, Japan	1985 - 1995	GARCH, FIGARCH	Perceived

Castrén, O. "Do options-implied RND functions on G3 currencies move around the times of interventions on the JPY/USD exchange rate?." (2004)	Japan	1992 - 2003	E-GARCH	Official
Edison, H.; Cashin, P.; Hong Liang."Foreign exchange intervention and the Australian dollar: has it mattered?." (2006)	Australia	1984 - 2001	GARCH	Official
Dominguez K. "When do CB FX interventions influence intra-daily and longer-term exchange rate movements?" (Working paper)	Germany, Japan	1989-1995	FIGARCH, OLS	-
Garcia-Verdu S. "Interventions and expected exchange rates in emerging market economies." (2013)	Mexico, Peru	2009-2013	OLS	-

Appendix C

Table 8. Group 1 (amount). Level, fixed effects estimation (Stata output)

Study	ES	[95% Conf.	Interval]	% Weight
Broto C. (C1) (2012)	-0.080	-0.198	0.038	0.01
Broto C. (C2) (2012)	0.200	0.167	0.233	0.09
Broto C. (C3) (2012)	0.040	-0.058	0.138	0.01
Broto C. (C4) (2012)	0.040	-0.009	0.089	0.04
Kim S.Y. et al (2010)	0.003	0.002	0.004	65.91
Kamil H. (2008)	0.782	0.214	1.350	0.00
Dominguez K. (1993)	-1.132	-1.211	-1.053	0.02
Dominguez K. (1993)	-0.111	-0.122	-0.100	0.86
Aguilar J. et al (2000)	-0.084	-0.085	-0.082	30.39
Beine M. et al (2002)	-0.113	-0.184	-0.042	0.02
Beine M. et al (2002)	-0.005	-0.020	0.011	0.45
Castren O. (2004)	-0.172	-0.873	0.530	0.00
Edison H. et al (2006)	0.011	0.004	0.017	2.20
I-V pooled ES	-0.024	-0.025	-0.023	100.00

Heterogeneity chi-squared=7106.03 (d.f.=12), p=0.000

I-squared (variation in ES attributable to heterogeneity) =99.8%

Test of ES=0: z=46.33, p=0.000

Table 9. Group 1 (amount). Volatility, fixed effects estimation (Stata output)

Study	ES	[95% Conf.	Interval]	% Weight
Broto C. (2012)	0.026	0.006	0.046	0.00
Broto C. (2012)	0.110	0.090	0.130	0.00
Broto C. (2012)	-0.010	-0.024	0.004	0.01
Broto C. (2012)	-0.020	-0.020	-0.020	39.66

Kim S.Y. et al (2010)	0.008	0.003	0.013	0.05
Kim S.Y. et al (2010)	0.000	-0.000	0.001	7.37
Dominguez K. (1998)	0.007	-0.015	0.028	0.00
Dominguez K. (1998)	0.003	0.001	0.005	0.28
Frenkel M. et al (2003)	0.000	0.000	0.000	39.66
Kamil H. (2008) (2002)	-0.019	-0.039	0.001	0.00
Dominguez K. (1993)	-0.161	-0.207	-0.115	0.00
Dominguez K. (1993)	0.192	0.167	0.217	0.00
Aguilar J. et al (2000)	-0.020	-0.031	-0.009	0.01
Beine M. et al (2002)	0.114	-0.007	0.234	0.00
Beine M. et al (2002)	0.035	0.013	0.056	0.00
Castren O. (2004)	-0.009	-0.043	0.024	0.00
Edison H. et al (2006)	0.000	0.000	0.001	12.95
I-V pooled ES	-0.008	-0.008	-0.008	100.00

Heterogeneity chi-squared=25355.72 (d.f.=16), p=0.000

I-squared (variation in ES attributable to heterogeneity) =99.9%

Test of ES=0: z=122.90, p=0.000

Table 10. Group 1 (amount). Level, random effects estimation (Stata output)

Study	ES	[95% Conf.	Interval]	% Weight
Broto C. (C1) (2012)	-0.080	-0.198	0.038	5.59
Broto C. (C2) (2012)	0.200	0.167	0.233	9.86
Broto C. (C3) (2012)	0.040	-0.058	0.138	6.53
Broto C. (C4) (2012)	0.040	-0.009	0.089	9.15
Kim S.Y. et al (2010)	0.003	0.002	0.004	10.57
Kamil H. (2008)	0.782	0.214	1.350	0.48
Dominguez K. (1993)	-1.132	-1.211	-1.053	7.52
Dominguez K. (1993)	-0.111	-0.122	-0.100	10.49
Aguilar J. et al (2000)	-0.084	-0.085	-0.082	10.57
Beine M. et al (2002)	-0.113	-0.184	-0.042	7.97
Beine M. et al (2002)	-0.005	-0.020	0.011	10.42
Castren O. (2004)	-0.172	-0.873	0.530	0.32
Edison H. et al (2006)	0.011	0.004	0.017	10.54
D+L pooled ES	-0.089	-0.129	-0.048	100.00

Heterogeneity chi-squared=7106.03 (d.f.=12), p=0.000

I-squared (variation in ES attributable to heterogeneity) =99.8%

Estimate of between-study variance Tau-squared=0.0040

Test of ES=0: z=4.30, p=0.000

Table 11. Group 1 (amount). Level, random effects estimation (Stata output)

Study	ES	[95% Conf.	Interval]	% Weight
Broto C. (2012)	0.026	0.006	0.046	5.23

Broto C. (2012)	0.110	0.090	0.130	5.23
Broto C. (2012)	-0.010	-0.024	0.004	6.56
Broto C. (2012)	-0.020	-0.020	-0.020	8.69
Kim S.Y. et al (2010)	0.008	0.003	0.013	8.28
Kim S.Y. et al (2010)	0.000	-0.000	0.001	8.68
Dominguez K. (1998)	0.007	-0.015	0.028	4.79
Dominguez K. (1998)	0.003	0.001	0.005	8.60
Frenkel M. et al (2003)	0.000	0.000	0.000	8.69
Kamil H. (2008) (2002)	-0.019	-0.039	0.001	5.23
Dominguez K. (1993)	-0.161	-0.207	-0.115	1.87
Dominguez K. (1993)	0.192	0.167	0.217	4.17
Aguilar J. et al (2000)	-0.020	-0.031	-0.009	7.23
Beine M. et al (2002)	0.114	-0.007	0.234	0.33
Beine M. et al (2002)	0.035	0.013	0.056	4.79
Castren O. (2004)	-0.009	-0.043	0.024	2.93
Edison H. et al (2006)	0.000	0.000	0.001	8.68
D+L pooled ES	0.010	0.003	0.017	100.00

Heterogeneity chi-squared=25355.72 (d.f.=16), p=0.000
I-squared (variation in ES attributable to heterogeneity) =99.9%
Estimate of between-study variance Tau-squared=0.0002
Test of ES=0: z=2.85, p=0.004

Appendix D

Table 12. Group 1 (amount). Level, Egger regression test

Source	**SS**	**df**	**MS**	**Number of obs = 13** **F(1, 11) = 1.91**
Model	1214.52775	1	1214.52775	Prob > F = 0.1940
Residual	6980.82001	11	634.620001	R-squared = 0.1482 Adj R-squared = 0.0708
Total	8195.34776	12	682.945647	Root MSE = 25.192

w_estimate	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
inverse_se	-.0207588	.0150056	-1.38	0.194	-.053786 .0122684
_cons	-3.563544	8.022572	-0.44	0.666	-21.22111 14.09402

Table 13. Group 1 (amount). Volatility, Egger regression test

Source	**SS**	**df**	**MS**	**Number of obs = 13** **F(1, 11) = 0.08**
Model	2.23355834	1	2.23355834	Prob > F = 0.7811

Residual	302.900587	11	27.536417	R-squared = 0.0073
				Adj R-squared = -0.0829
Total	305.134145	12	25.4278454	Root MSE = 5.2475

w_estimate	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
inverse_se	.0001392	. 0004887	0.28	0.781	-.0009364	.0012148
_cons	1.186173	1.67178	0.71	0.493	-2.493389	4.865735

Appendix E

Table 14. Group 2 (fact). Volatility, fixed effects estimation (Stata output)

Study	ES	[95% Conf.	Interval]	% Weight
Dominguez K. (Working paper)	0.296	0.167	0.425	0.00
Dominguez K. (Working paper)	0.317	0.213	0.421	0.00
Garcia-Verdu S. (2014)	-0.006	-0.010	-0.002	0.07
Garcia-Verdu S. (2014)	-0.000	-0.000	0.000	99.92
Dominguez K. (1998)	-0.015	-0.023	-0.007	0.02
I-V pooled ES	-0.000	-0.000	0.000	100.00

Heterogeneity chi-squared=79.31 (d.f.=4), p=0.000

I-squared (variation in ES attributable to heterogeneity) =95.0%

Test of ES=0: z=1.52, p=0.129

Table 15. Group 2 (fact). Volatility, random effects estimation (Stata output)

Study	ES	[95% Conf.	Interval]	% Weight
Dominguez K. (Working paper)	0.296	0.167	0.425	0.89
Dominguez K. (Working paper)	0.317	0.213	0.421	1.34
Garcia-Verdu S. (2014)	-0.006	-0.010	-0.002	33.25
Garcia-Verdu S. (2014)	-0.000	-0.000	0.000	34.35
Dominguez K. (1998)	-0.015	-0.023	-0.007	30.17
I-V pooled ES	-0.000	-0.012	0.013	100.00

Heterogeneity chi-squared=79.31(d.f.=4), p=0.000

I-squared (variation in ES attributable to heterogeneity) = 95.0%

Estimate of between-study variance Tau-squared=0.0001

Test of ES=0: z=0.04, p=0.966

Appendix F

Table 16. Group 2 (fact). Volatility, Egger regression test

Source	SS	df	MS	Number of obs = 5
				F(1, 3) = 0.19

Model	4.88020402	1	4.88020402	Prob > F = 0.6901
Residual	75.8532911	3	25.2844304	R-squared = 0.0604
				Adj R-squared = -0.2527
Total	80.7334952	4	20.1833738	Root MSE = 5.0284

w_estimate	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
inverse_se	-.0001247	.0002838	-0.44	0.690	-.001028 .0007786
_cons	.9392471	2.53983	0.37	0.736	-7.143626 9.02212

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DETERMINATION OF ABNORMALLY LOW PRICE: CASE OF UKRAINE

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ABSTRACT

Cases of abnormal decreases in auction prices within the Prozorro system draw attention of researchers and reformators. This work is aimed at determination of abnormally low price within the procurement system of Ukraine and development of methodology and recommendation on prevention of negative consequences caused by the abnormally low price. The maximum bidding step (according to the methodology of the World Bank for definition of abnormally low prices) was established for two auction groups: with two and more participants, and also three and more participants based on logit and linear regressions. In addition, authors defined (according to CPV codes) sectors (according to CPV codes) with the highest likelihood of abnormal low prices.

Key words: public procurement, Prozorro, abnormally low price
JEL classifications: D44, H57, C57

1. Introduction

After the introduction of Prozorro public procurement system in Ukraine there has been a question of mitigation of negative effects emerging during the procurement process and upon signing and implementation of an agreement. A range of these problems might be solved by setting a maximum bidding step for decreasing the price in the initial (during the initial bidding) and/or in the next rounds of the auction.

Today, for a price decreasing during an e-auction there is a rule – a purchasing agent defines a minimal bidding step for price decrease. The maximum price step is not defined by Ukrainian legislation, but it enables finding of abnormally low prices (those which are lower than expected price, for example). Abnormally low

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price (ALP) may be considered as an attempt to sabotage an auction and win tender (namely: decrease in competition, declination to sign an agreement, termination of an agreement, corruption through supplementary agreements). The mechanisms that prevent such prices, unfortunately, do not exist in Ukraine, but these are established in other countries, for example, the EU countries and Georgia.

Ukrainian system does not have a feasible methodology of preventing ALP, therefore the necessity of automatic system declining ALP arises. Another question is this right should go to the organizers of the auction, who are empowered to ask for documented information on cost of production of goods, or services. There is a need to define the procedure of ALP identification, as some price might be abnormally low for one participant, but "normal" for another. Also, there is a need in development of court appeal procedure for auction participants, whose price was recognized by a court as abnormally low, and outline the responsibility of the parties for risks, connected to ALP setting.

This research is aimed at determination of ALP and development of methodology and recommendations for Ukraine. The described methodology will allow to define a deviation from a bid price in the initial "blind" round or in the third round comparing to the average bids of other auction participants or expected price. Particularly, four indicators («GAP») will be calculated as independent variables. After that the negative results will be defined (which are a dependent variable), serving as an aggregate indicator («NE») of the level of auction results «deviation». In order to check every single bid one will use the model, results of which will provide enough information for the following analysis.

The developed model will allow: 1) testing the effect of ALP on auction results and purchases at all; 2) to determine a formula for the ALP calculation; 3) determination of the increasing in a deviation level between the bids of participants and expected value or average of bids in the initial round; to identify negative results of the maximum auction step absence; offer the markets (goods or services), which are suitable for "trial" projects on ALP introduction for checking the results.

2. Literature review

The Law of Public and Utilities Procurement by The World Bank [8] provides the following definitions of ALP: «Abnormally low price / offer is such a price / offer, in which price / offer together with other components of a price / offer looks so low, that it questions the ability of a Participant / Borrower to fulfil a contract at the offered price». The World Bank distinguishes two approaches to identification of ALP depending on the amount of received bids/offers. In the case with 5 or less ALP bids an 'absolute' approach is applied, which compares the initial price and its components. Under the 'relative' approach one implies statistical calculation involving at least 5 prices. A price is considered as abnormally low if the low bid is more than one standard deviation below the average bid value.

Directive 2004/18/EC of the European parliament and of the council on public procurement [2] considers the phenomenon of ALP under the definition «abnormally low tender» (ALT). The process of ALT detection is the following: 1) regulatory authority does not have to investigate ALT; 2) regulatory authority is not allowed to decline the tender without a request to participants for a written justification of

the price offer; 3) mathematic calculations can be applied only as indicators of ALTs, which may need explanation. 8 out of 28 EU countries use an identical to the World Bank approach – 'absolute' and 'relative' estimation systems. 'Relative' standards check for deviations of a tender from the average tender offers, while 'absolute' standards check for deviations from estimated costs. A competitive edge of 'relative' over 'absolute' standards is reflection of real market conditions, while its drawback lies in a possibility of manipulations and minimal amount of bids requirement.

OECD provides its analysis of ALP practices, which are applied by different countries [9]. It should be noted, that many OECD members do not have any certain method of abnormally low tender offers defining.

ALP is described in the researches of Arrowsmith [7-9], which define ALP as a price, which does not let participants negotiate and fulfil a contract. In the article dated 2014 the definition of ALP was extended by with points regarding non-fulfillment of legal agreement and obligations. For example, there was a case of court appeal regarding ALP in Spain [5]. And even though the appeal was not satisfied, this precedent allowed deepening of the decision-making procedure on the regulator level. Another country encountering ALP is the Republic of Azerbaijan. A regulatory authority identified several reasons behind low bids: competitive market, lack of materials, expectation of compromise with tender organizers, incompetence of the personnel in work with the system. It should be noted, that the procurement system of the Republic of Azerbaijan allows declination of low bids – Article 2.7.4: «In case of a significant difference between the price of any tender offer and expected price of the respective goods/services. A client has a right to decline an offer. This decision should be approved by the respective executive body» [3].

Definition of ALP through mathematical calculations implies, that a price bid is competitive and independent. Namely, there is no price collusion on the market, which artificially fixes the prices. Arithmetical methods of ALP identification are applied in some countries, such as Italy, Poland, Portugal, Romania, Slovakia, and Slovenia (Table 1). These methods are based on comparison of the tender price with the expected purchase price, average price of the submitted tender offers or differences between the lowest and second lowest price offers.

Table 1. Methods of ALP identification in the EU countries

Country	Deviation of participants' bid	Other
Italy	Example: if there are 11 bids (with deviation of 8% - 25%), then 16%.	• at least 16/20 points for price; • at least 64/80 points for other quality indicators
Poland	30%	No data available
Portugal	• 40% or more for construction contracts; • 50% or more for other agreement types	ALT is defined when a price is lower than the set by the client budget price («basic price»)
Romania	• 85% (less than 5 participants); • 85% not considering minimum and maximum submitted prices (more than 5 participants)	Absent in the new edition of the Law on Public Procurement (2016)
Slovakia	15% / 10%	At least 3 participants

Source: [1], [3], [5], [9]

3. Description of the data

Prozorro database (bipro.prozorro.org.ua) was used in the research. The sample consists of 537,742 observations with the following restrictions:

- Time period for analysis is September 2016 – August 2017;
- Status of the lot is "closed";
- Procurement procedure includes competitive bargaining (public auction, public auction with publication in English, subthreshold procurement);
- Prices are indicated in hryvnias;
- Since one participant can take part in the subthreshold procurement (by negotiating procedure), data on them are excluded from the analysis. That is, if a number of participants in the lot is less than 2, such lots are excluded from the sample.

In general, there are two types of auctions: superthreshold (206,024 observations) and subthreshold auctions (331,718 observations). 182,280 lots were analysed.

In the aggregate, 33,087 additional agreements (25,942 lots) were concluded during the time period, which equals 1 additional agreement per 7 lots. The mains reasons for signing additional agreements were the following: change in a price per unit of good (32.1% of all the additional agreements), quality improvement of the procurement item (18.5%) and decrease in purchasing volume.

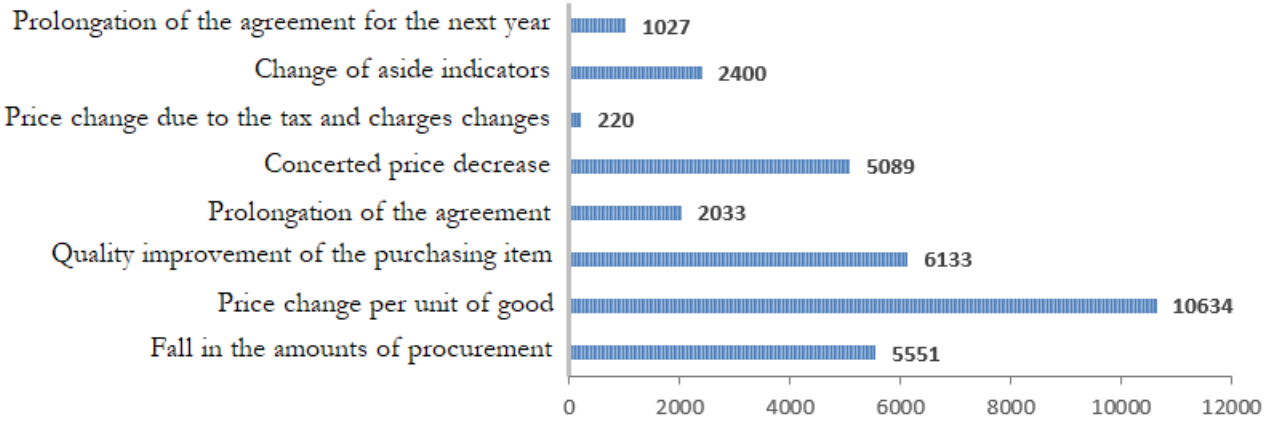

Figure 1. Distribution of the additional agreements
Source: own calculations

The highest share of additional agreements was observed in the following fields (according to the classification provided by the Common Procurement Vocabulary): "Hotel and Restaurant Services and retail services" (19.1%), "Oil products, fuel, electricity and other sources of energy" (18.1%), "Agricultural and farm products, products of fishery and forestry and related products" (11.83%).

According to the sample data, 2,817 agreements, concluded as a result of price proposal winning, were terminated. 44.2% of agreements were terminated due to failures to perform an agreement by one party, improper quality of goods / services provided, no supply of goods / services or price increase for goods /

services.

If bids of a participant were the same in each of the three rounds of an auction, then it is deemed that the participant is noncompetitive. 51.9% of the participants in the sample were not active, 48.1% change their bids over the dynamic auction (that is, they competed).

According to a participant's status (variable with the name LotBidStatus), the participant won in a tender (at the level of lots) in 34.9% of cases; the participant lost with higher price than the winner's price in 29.3% of cases; in 23.8% of cases the price proposal wasn't considered and in 11.8% of cases the participant was disqualified. In other cases, the price proposal was annulled or to be considered later (together accounting for 0.2% of cases).

The main variables used in further calculations are the following:

- InitPricePropos – a participant's bid in the "blind" round;
- ExpVal – expected value;
- R3 – a participant's bid in the third round;
- Date – publication date of procurement;
- IsVATincluded – a ficititious parameter (1 – VAT is included, 0 – VAT is not included);
- NumberBidders – a number of bidders (the obtained results are different from the information on Prozorro. Since non-numbered lots don't provide a correct number of participants, in order to get the exact number of them authors performed their own calculations);
- i.Purchase – a categorical parameter (1 – goods, 2 – services, 3 – works), developed on the basis of CPV classifier; markets were designated by first two digits determining a section: below 45 – goods, 45 – works and above 45 – services;
- i.Region – a categorical parameter (1 – West, 2 – North, the Central Part, 3 – East; 4 – South, 5 – other countries);
- BelowThresholdness – a fictitious parameter (1 – superthreshold, 2 – subthreshold);
- NumberDays – a number of days between publication and conclusion of an agreement.

Full description and analysis of the data structure is specified in the Appendix A.

4. Methodology

ALP can be determined in the following ways ("GAP"):

1. GAP1 – deviation of a participant's bid in % in the null round (InitPricePropos) compared to an average bid of all participants in the "blind" round:

$$gap1 = \frac{(mean(InitPricePropos) - InitPricePropos)}{mean(InitPricePropos)} * 100\%$$

2. GAP2 – deviation of a participant's bid in % in the third round (R3) compared to an average bid of all participants in the "blind" round:

$$gap2 = \frac{(mean(InitPricePropos) - R3)}{mean(InitPricePropos)} * 100\%$$

3. GAP3 – deviation of a participant's bid in % in the null round compared to an expected value:

$$gap3 = \frac{(ExpVal - InitPricePropos)}{ExpVal} * 100\%$$

4. GAP4 – deviation of a participant's bid in % in the third round compared to an expected value:

$$gap4 = \frac{(ExpVal - R3)}{ExpVal} * 100\%$$

To estimate the maximum step of a participant, authors used 2 non-liners models with variables GAP and GAP squared in order to receive a marginal value of the maximum step for lots, where the number of participants exceed 1 and 2 as well as 4 logit regressions with dependent variables being negative consequences and independent variables being control ones, GAPs and 20 variables (GAP0_5, GAP5_10, …, GAP95_100), which have to specify the probability of a negative effect in certain range (for instance, a coefficient before GAP5_10 shows the probability of a negative effect when "GAP" is in the range from 5 to 10%). First two logit regressions indicate the likelihood of negative event depending on the value of GAP for lots with 2 and 3 and more participants. Last two logit regressions include independent vatiables GAP0_5, GAP5_10 etc for lots with 2 and more as well as 3 and more participants.

Negative effects (NE) of ALP are shown by the dependent variable, expressed by:

1. The status of price offers (LotBidStatus):

3 – a participant is disqualified,

4 – price proposal is not considered,

5 – price proposal is annulled,

6 – price proposal is to be considered.

If there is a negative effect with variable LotBidStatus taking a value from 3 to 6 in the sample, then NE becomes of a value 1.

2. *The variable !mi* (terminationsDetails) shows whether an agreement with the winner of an auction was terminated or not.

3. *If there is a negative effect with terminationDetails* filled in the sample (that is, there is a comment regarding the termination of the agreement or specific violation), then NE becomes of a value 1.

4. *The variable TypeChanges* shows a reason for concluding an agreement. If there is a negative effect with variable TypeChanged and it takes a value from 1 to 8 in the sample, then NE becomes of a value 1.

5. *The variable NoComp* indicates an incentive of other participant towards competition (if the variable is equal to 1, then other participant at the auction don't compete; if the variable is equal to 0, then other participants compete).

15 scenarios with negative events were considered (for instance, ALP of one of the bidders leads to unwillingness of other bidders to lower the price during the dynamic auction and / or there is a termination of the agreement – NE9). The list of different combinations of negative effects is shown in the Table 2.

Table 2. List of combinations of different negative effects (NE)

	Absence of competition (AC)	**Additional agreement signed (AA)**	**Agreement is not signed (NS)**	**Agreement is terminated (AT)**	
NE1	AC		AA	NS	AT
NE2			AA	NS	AT
NE3	AC			NS	AT
NE4	AC		AA		AT
NE5	AC		AA	NS	
NE6				NS	AT
NE7			AA		AT
NE8			AA	NS	
NE9	AC				AT
NE10	AC			NS	
NE11	AC		AA		
NE12					AT
NE13				NS	
NE14			AA		
NE15	AC				

Source: authors' own estimates

Formulars to determine the level of ALP are provided below:

1. Linear model formula (OLS, GAP for lots with 2 and more as well as 3 and more bidders):

$$NE`y' = Date + IsVATincluded + NumberBidders + i.Purchase + i.Region + BelowThresholdness + gap`x' + gap`x'\ \hat{}\ 2 + NumberDays$$

2. Logit model formula (with GAP in % for lots with 2 and more as well as 3 and more bidders):

$$NE`y' = Date + IsVATincluded + NumberBidders + i.Purchase + i.Region + BelowThresholdness + gap`x' + NumberDays$$

3. Logit regression formula (with dummy-GAP for lots with 2 and more as well as 3 and more bidders):

NE`y' = Date + IsVATincluded + NumberBidders + NumberDays + i.Purchase
+ i.Region + BelowThresholdness + GAP0_5_`x' + GAP5_10_`x' + GAP10_15_`x'
+ GAP15_20_`x' + GAP20_25_`x' + GAP25_30_`x' + GAP30_35_`x' + GAP35_40_`x'
+ GAP40_45_`x' + GAP45_50_`x' + GAP50_55_`x +' GAP55_60_`x' + GAP60_65_`x'
+ GAP65_70_`x' + GAP70_75_`x' + GAP75_80_`x' + GAP80_85_`x' + GAP85_90_`x'
+GAP90_95_`x' + GAP95_100_`x'

"x" stand for the GAP number from 1 to 4 while "y" stands for NE combination number from 1 to 15.

5. Results

Using a statistical package STATA authors analyzed 360 cases of relationship between the size of GAP and negative effects (NE) – 6 types of regression*, 4 types of GAP*, 15 combinations of negative effects. The results of the regression analysis are represented in Table 3.

Table 3. Logit-models (with statistically significant odds-ratios between the GAP та dummy-GAP variables)

GAP in % (from 3 participants / from 2 participants)	GAP1	GAP2	GAP3	GAP4	Dummy GAP (from 3 participants/from 2 participants)	GAP1	GAP2	GAP3	GAP4
NE1	-/-		-/+		NE1	↓/		>90↑/	
NE2	-/-	-/-	-/-	-/-	NE2	↓/	>90↑	>90↑/ randomly	↓/ randomly
NE3	-/-		-/+		NE3	>85↑/		>90↑/	
NE4	+/+		+/+		NE4	<40↑		<90↑	
NE5	-/-		-/+		NE5			>95↑/	
NE6	-/-	-/-	-/-	-/-	NE6		>90↑	>90↑	↓/>90↑
NE7	+/+	+/+	/+	-/-	NE7		/↑	↑	↑
NE8	-/-	-/-	-/-	-/-	NE8		>90↑	>90↑/ randomly	↓/ randomly
NE9	+/+		+/+		NE9	<35↑		<75↑/<70↑	
NE10	-/-		-/+		NE10			>95↑/	
NE11	+/+		+/+		NE11	<35↑		<80↑	
NE12	+/+	+/+	+/+	+/+	NE12	↑	↑	↑	↑
NE13	-/-	-/-	-/-	-/-	NE13	>80↑/ >65↑	>90↑	>90↑	↓/>90↑
NE14	+/+	-/+	-/+	-/-	NE14			<70↑	<85↑/<90↑
NE15	+/+		+/+		NE15	<35↑		<70↑/ <75↑	

Source: authors' own estimates

Comment: if the data in cells does not contain a slash (/), then it is true for both lots with 2 and more participants, as well with 3 and more participants. For example, if size of GAP2 is larger than 90%, then probability of NE2 or NE6 outcomes increases (for a detailed description of NE refer to Table 2).

According to results, represented in the table above, one may conclude the following:

• If the absence of competition in not accounted for, then the effect of additional agreements, as well as termination or cease of an agreement is inversely related to increase in deviation of bids. In case of GAPs measured in % (for NE4, NE9, NE11, NE12, NE15): absence of competition, signing of additional agreements and termination of agreements happens after an increase in GAP1 and GAP3. At the same time, cease of agreement signing does not increase probability of NE outcomes in these cases.

• Probability of making additional agreements and termination of agreements (NE7, NE12, NE14) increases only in cases if a participant decreases a bid significantly in the 3 round comparing to the average bid of initial (zero) round.

• If one compares the difference in results between the models including lots with 2 and more participants and lots with higher number of participants, then decrease of the bid and respective increase in the difference between the bids in GAP3 raises probability of NE outcome for lots with 2 and more participants. Alternatively, it decreases probability for lots with 3 and more participants.

• When calculating GAP1 as a dummy variable, probability of additional agreements does not increase due to a decrease in participants' bids, but it decreases alternatively in response to greater difference between the bids.

• In order to decrease probability of ceased agreements, the maximum difference between a bidding step and average value of bids during a "blind" round should be set at the level of 65% (for lots with 2 and more participants) and 80% (for lots with 3 and more participants). Additionally, for the sake of a decrease in probability of agreement termination and dealing with low competition during auction a maximum value of bidding step should not exceed 85%.

• Identification of ALP with a 90% deviation from the average value of bids during the "blind" round decreases the probability of NE2, NE6, NE8, NE13 outcomes. Namely, it is related to cease of agreement signing by a participant, as well as introduction of additional agreements and termination of contracts.

• Analysis of a bid's deviation in the "blind" round relative to its expected price showed a maximum step at the level of 90% (NE1, NE2, NE3, NE6, NE8, NE13) for a decrease in probability of all NE outcomes: absence of competition during bidding, cease of agreement signing, termination of agreements, and introduction of additional agreements.

• Analyzing only controlled by law part of auction (price decrease by participants during bidding in order to achieve the final goal of signing an agreement), it is enough to raise the threshold of ALP identification to 95%.

• It should be noted, that the problem of participants' unwillingness to compete after a significant decrease of one bid in a "blind" round relative to its expected value is not observed here. This fact proves that potential sellers evaluate the work, goods or services with prices, different from procurement or market prices.

• During calculation of GAP3 and GAP4 there were 2 assumptions: 1) participants of bidding learn over time how to behave during an auction, win, sign an agreement and fulfilling their obligations without any negative effects; 2) organizers of bidding learn over time how to fill out tender documentation with precise indication of procurement object's characteristics. They set the expected value at the market price level or

according to prices of previous procurement agreements with respective CPV codes.

But these assumptions are somehow neglected by statistically significant odds-ratios of a time variable (date of procurement announcement publication) at the level 1 for all methods of combining NE and calculating GAPs. Therefore, organizers and participants of an auction do not change their behavioral strategies at Prozorro auctions and NEs are present.

• A great decrease in a participant's bid in GAP4 has no impact on signing or termination of an agreement, regardless of presence or absence of an additional agreement. Moreover, such a decrease sometimes may have an inverse relationship. The reason behind this situation is an effective (healthy) competition during dynamic auction.

• Identification of ALP when a bid deviates by 95% in GAP4 decreaes probability of signing the agreement by participants significantly.

Table 4. Definition of ALP level according to marginal value (excluding values more than 100% and those close to zero)

GAP in %	GAP1	GAP2	GAP3
NE1	/30		/69
NE2			
NE3	/42		/72
NE4	87/92		65/65
NE5	/33		/68
NE6			
NE7		34/	/59
NE8			
NE9			67/67
NE10	/46		/71
NE11	85/89		64/65
NE12			
NE13			
NE14			/57
NE15	93/91		66/67

Source: authors' own estimates

According to the results of the Table 4 above one may conclude the following on the basis of the coefficients of the linear model:

• The difference between a participant's bid in the third round and an expected value has shown that there exists a competition among participant in the 3-round auction. There are no other negative consequences due to the high value of GAP4. Therefore, it is worthless to determine ALP by GAP4.

• It is not optimal to decrease negative effect of non-signing, signing with additional agreement, termination of an agreement without regard to the impact of no competition during the bargaining.

• For lots with 3 and more participants ALP should be set at the level of 35% to reduce the likelihood

of termination of contracts and 85-90% - to decrease likelihood of non-willingness of participants to reduce price.

• Comparing deviations of bids in the null round with expected value or with average bids of the "blind" round (GAP1 and GAP3 respectively), one can observe that for lots with 2 and more participants ALP differ by 30-40% and constitute 60-70% (for GAP1) and 30-40% (for GAP3). Moreover, ALP at the level of 85-90% reduce the likelihood of negative events if no account is taken of non-signing of contracts by participants.

To proceed further with the "pilot" project, markets (for goods, works and services) were designated with the below mentioned respective methods to calculate the maximum step in the auction (G- goods, W – works, S – services).

Table 5. The effect of lower price on the NE in different markets (statistically significant odds-ratio of variable Purchase are provided below)

Purchase	GAP1	GAP2	GAP3	GAP4
NE1	G		G	
NE2	W	G	G,W	S,W
NE3	G		G	
NE4	G		G	
NE5	G		G	
NE6	W	П	S,W	S,W
NE7	W	G,W	G,W	G,W
NE8	W	S,W	G,W	S,W
NE9	G		G	
NE10	G		G	
NE11	G		G	
NE12	G	G	G,S	G
NE13	W	S,W	S,W	S,W
NE14	G,W	G,W	G,W	G,W
NE15	G		G	

Source: authors' own estimates

Summing up the results from Table 5, one may conclude the following:

1. GAP1. In the market of works lower competition is not accounted for because of the higher gap. In the goods market higher probability of all cases occurring at the same time is the result of higher deviation of a participant's bid from the average bid of all participants in the "blind" round.
2. GAP2. The market of works has the highest direct impact of the GAP2 increase on the likelihood of non-signing, signing with additional agreements, termination of an agreement. At the same time, there is higher likelihood of signing additional agreements in the service market and non-signing of contract in the goods market.
3. GAP3. The likelihood of all NE occurring in the goods market is higher than in the service and works markets.
4. GAP4. The likelihood of agreement termination is higher in the service market while in the goods

market there is higher likelihood of signing additional agreements and/or termination of agreement.

Additional control variables have shown that mainly during superthreshold procurements the likelihood of negative events increases with higher deviation of a participant's bid. Subthreshold procurements are widely characterized by signing additional agreements, notably because of significant price fall by bidders during the bargaining (for all 4 type of GAPs). The bigger the number of bidders, the higher the likelihood of negative events, except for NE7, NE12 and NE14. That is, for all GAPs with the number of bidders increasing, the likelihood of additional agreements conclusion and/or termination decreases.

6. Conclusions

Abnormally low price (ALP) is considered in the world practice of public procurement as an attempt to sabotage an auction aiming at winning a tender (lowering competition, refusing to sign an agreement, terminating an agreement, corrupting through additional agreements). Unfortunately, there are no preventive arrangements regarding the setting of such prices in Ukraine, however they exist in other countries, in particular European Union countries.

One of the ALP remedy for Ukraine is the establishment of the maximum step (according to the methodology of the World Bank on the ALP determination), after which an auction organizer or a regulator is entitled to check a participant and require documental confirmation as well as calculations of the costs of goods, services or works.

According to the research results, in order to lower likelihood of non-signing of an agreement, the maximum step, that is deviation of a participant's bid in the null round compared to an average of all participants' bids in the "blind" round, should be set at the level of 65% (for lot with 2 and more participants) and 80% (for lots with 3 and more participants). In addition to lower likelihood of agreement termination and to avoid a case of no competition during the auction, maximum step should be 85%. ALP determination at the deviation of a bid in the third round compared to the average of bids in the "blind" round at the level of 90% lowers likelihood of, firstly, non-signing of an agreement by a participant, and, secondly, conclusion of additional agreements and termination of contract.

Analysis of deviations of a participant's bid in the "blind" round compared to an expected value showed that the maximum step should be at the level of 90% in order to increase likelihood of all NE: no competition during the bargaining, non-signing of agreements, conclusion of additional agreements and termination of contracts. It should be noted that a separate problem of participants' unwillingness to compete when one of the participants has significantly lowered his/her bid in the "blind" round compared to an expected value is not evident. This fact can signify that potential sellers value goods, works or services at prices different from procurement or market prices.

ALP can use as a "pilot" version in the superthreshold procurements in the goods market corresponding to the CPV code <44. For the annual time period, which was studied, the highest share of additional signed agreements characterized the markets for "Oil products, fuel, electricity and other sources of energy", "Agricultural and farm products, products of fishery and forestry and related products"; the highest share of disqualified participants characterized the marker for "Clothes, shoes, bags and accessories", "Electrical

equipment, machines, instruments and materials; lightning equipment".

One should note that experience of other countries lets us develop legislature in order to specify procedures of making appeals to court in the event of abnormally low prices.

To proceed further, maximum step is recommended to be set at the level of 65% for participants in the "blind" round for lots with 2 and more participants and at the level of 80% for lots with 3 and more participants.

Appendix A. Description the data used

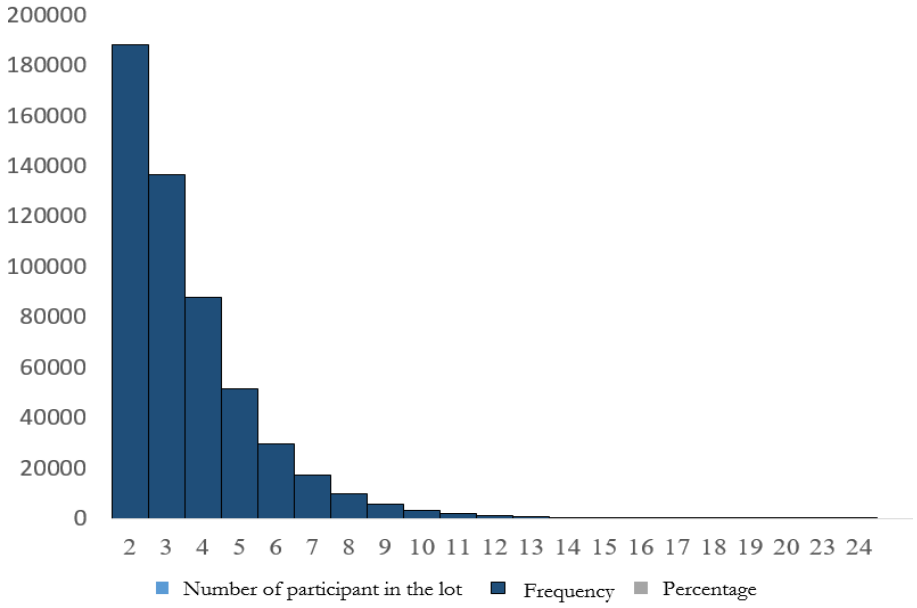

Figure 2. Histogram "Distribution of participants in the sample"

Source: authors' own estimates

Table 6. Distribution of participants in the sample

Number of participant in the lot	Frequence	Percentage
2	188272	35.01
3	136755	25.43
4	88020	16.37
5	51535	9.58
6	29952	5.57
7	17353	3.23
8	10152	1.89
9	5913	1.1
10	3540	0.66

11	2277	0.42
12	1260	0.23
13	936	0.17
14	532	0.1
15	300	0.06
16	384	0.07
17	153	0.03
18	198	0.04
19	76	0.01
20	40	0.01
23	46	0.01
24	48	0.01
Total	**537,742**	**100**

Source: authors' own estimates

Table 7. Distribution of participant in the sample by variables "NumberBidders" (the number of participant from bipro.prozorro.org.ua), "NumberPropos" (calculation of the number of participants at the level of lots)

```
. tab NumberBidders
```

Number of bidders of lot	Freq.	Percent
1	41	0.01
2	196,498	36.54
3	135,175	25.14
4	85,299	15.86
5	49,661	9.24
6	28,939	5.38
7	16,662	3.10
8	9,985	1.86
9	5,724	1.06
10	3,562	0.66
11	2,268	0.42
12	1,267	0.24
13	887	0.16
14	532	0.10
15	300	0.06
16	384	0.07
17	153	0.03
18	198	0.04
19	76	0.01
20	40	0.01
23	46	0.01
24	48	0.01
Total	537,745	100.00

```
. tab NumberPropos
```

Number of bidders of lot	Freq.	Percent
1	3	0.00
2	188,272	35.01
3	136,755	25.43
4	88,020	16.37
5	51,535	9.58
6	29,952	5.57
7	17,353	3.23
8	10,152	1.89
9	5,913	1.10
10	3,540	0.66
11	2,277	0.42
12	1,260	0.23
13	936	0.17
14	532	0.10
15	300	0.06
16	384	0.07
17	153	0.03
18	198	0.04
19	76	0.01
20	40	0.01
23	46	0.01
24	48	0.01
Total	537,745	100.00

Source: authors's estimates

Table 8. The distribution of additional agreements by CPV[2] classifier

CPV	1	2	3	4	5	6	7	8	Share, %
03	2.49	5.47	1.25	0.37	1.51	0.02	0.57	0.15	11.83
09	3.10	9.47	1.72	0.42	2.03	0.15	0.87	0.30	18.06
14	1.41	3.93	0.77	0.55	1.33	0.00	0.25	0.61	8.85
15	2.31	6.66	1.09	0.23	0.86	0.04	0.44	0.05	11.69
33	0.92	0.85	1.62	0.17	1.72	0.13	0.58	0.32	6.30
34	0.34	0.49	1.15	0.68	1.54	0.01	0.36	0.56	5.14
45	0.80	0.12	2.88	1.79	1.64	0.04	1.17	0.31	8.76
55	9.76	0.33	4.60	0.33	2.85	0.08	0.68	0.48	19.09
63	2.66	0.00	3.89	0.61	3.07	0.00	2.46	0.00	12.70
85	1.30	0.27	2.60	1.99	1.03	0.00	2.05	1.10	10.34
98	2.92	0.19	1.75	0.68	1.46	0.00	1.65	0.00	8.65

Source: authors' own estimates

Table 9. Distribution of bidders' status according to the results of tender by CPV classifier[3]

CPV Classifier	1	2	3	4	5	6	Total	Total 3-4-5-6	Dataset	Share, %
66	643	581	218	1011	1	1	2455	1231	2455	50.14
76	193	164	124	200	0	0	681	324	681	47.58
31	6730	5956	2913	8504	19	16	24138	11452	24138	47.44
18	3745	3200	1633	4517	10	4	13109	6164	13109	47.02
22	3350	3058	821	4403	12	3	11647	5239	11647	44.98
39	10807	9502	4185	11748	65	11	36318	16009	36318	44.08
30	13554	12048	4852	13892	57	10	44413	18811	44413	42.35
37	1700	1378	857	1328	9	2	5274	2196	5274	41.64
42	4456	3866	2009	3884	18	11	14244	5922	14244	41.58

[2] Note. 1. Fall in the amounts of procurement; 2. Price change per unit of good; 3. Quality improvement of the procurement item; 4. Prolongation of the agreement; 5. Concerted price decrease; 6. Price change due to the taxes and charges changes; 7. Change of aside indicators; 8. Prolongation of the agreement for one additional year.

[3] 1 – a participant has won; 2 – a participant hasn't won (with higher price); 3 – a participant is disqualified; 4 – price proposal is not considered; 5 – price proposal is annulled; 6 – price proposal is to be considered.

44	11080	9716	4255	9753	51	27	34882	14086	34882	40.38
16	688	563	360	483	3	0	2097	846	2097	40.34
71	3785	3154	1688	2925	10	3	11565	4626	11565	40.00

Source: authors' own estimates

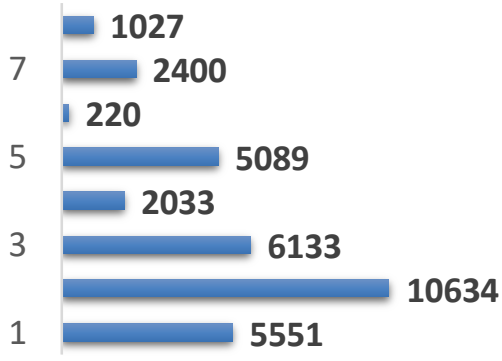

Figure 3. The distribution of additional agreements in the sample by the classifier CPV
Source: authors' own estimates

Table 10. Structure of auctions by the parameter NoComp.[4]

NoComp	Frequency	Percentage
0	258,541	48.08
1	279,201	51.92
Total	**537,742**	**100**

Source: authors' own estimates

Table 11. Structure of auctions by the parameter LotBidStatus[5]

LotBidStatus	Frequency	Percentage
1	187668	34.9
2	157710	29.33
3	63413	11.79
4	128117	23.82
5	581	0.11
6	253	0.05
Total	**537,742**	**100**

Source: authors' own estimates

[4] Note. 0 – no competition, 1 – there is competition.
[5] Note. 1 – a participant has won; 2 – a participant has lost with higher price; 3 – a participant is disqualified; 4 – price proposal is not considered; 5 – price proposal is annulled; 6 – price proposal is to be considered.

Table 12. The structure of auction by the reason of termination of contract

Termination of contract	Number of lots
By consent of the parties or due to force majeure	1194
Termination of an agreement	33
Reorganization/liquidation of a supplier/organizer, change in the main type of activity	223
Decrease in the demand of procurement/budget financing	121
Termination of contract due to failure to perform a contract by a Supplier; improper quality of goods/services; no deliveries of goods/services; price increase	1246
Total	**2817**

Source: authors' own estimates

Appendix B. The result of the logit regression

Table 13. GAP1 (deviation of a participant's bid in % in the null round (InitpricePropos) compared to the average of all participants' bids in the "blind" round), for lots with 2 and more participants

1	Date	1.000
		(3.96)**
	IsVATincluded	1.072
		(4.02)**
	NumberBidders	1.164
		(52.70)**
	2bn.Purchase	0.955
		(2.99)**
	3.Purchase	1.792
		(32.96)**
	2bn.Region	0.893
		(6.77)**
	3.Region	0.906
		(4.63)**
	4.Region	0.899
		(5.99)**
	5.Region	1.114
		(0.46)
	BelowThresholdness	0.489
		(51.47)**
	GAP0_5_1	2.929
		(86.55)**
	GAP5_10_1	6.130
		(116.88)**
	GAP10_15_1	7.989
		(109.15)**
	GAP15_20_1	9.251
		(94.85)**
	GAP20_25_1	10.430
		(81.24)**
	GAP25_30_1	11.408

		(68.19)**
	GAP30_35_1	12.745
		(57.71)**
	GAP35_40_1	13.381
		(46.92)**
	GAP40_45_1	13.073
		(38.13)**
	GAP45_50_1	13.363
		(30.85)**
	GAP50_55_1	12.414
		(23.09)**
	GAP55_60_1	13.680
		(18.67)**
	GAP60_65_1	9.989
		(13.86)**
	GAP65_70_1	5.506
		(8.36)**
	GAP70_75_1	10.138
		(9.42)**
	GAP75_80_1	10.070
		(7.44)**
	GAP80_85_1	0.572
		(1.05)
	GAP85_90_1	2037621464.048
		(0.01)
	GAP90_95_1	0.182
		(1.07)
	GAP95_100_1	2.461e+60
	NumberDays	0.985
		(20.16)**
2	Date	0.998
		(8.51)**
	IsVATincluded	1.412
		(3.44)**
	NumberBidders	0.672
		(13.47)**
	2bn.Purchase	1.288
		(3.34)**
	3.Purchase	1.075
		(0.64)
	2bn.Region	0.860
		(1.56)
	3.Region	0.857
		(1.24)
	4.Region	1.235
		(2.14)*
	5.Region	0.167
		(0.63)
	BelowThresholdness	0.478
		(10.97)**
	GAP0_5_1	3.493
		(19.73)**
	GAP5_10_1	3.561
		(12.71)**
	GAP10_15_1	3.731
		(9.63)**
	GAP15_20_1	4.929
		(9.85)**

	GAP20_25_1	4.275
		(6.41)**
	GAP25_30_1	4.344
		(5.07)**
	GAP30_35_1	7.415
		(6.88)**
	GAP35_40_1	8.380
		(5.95)**
	GAP40_45_1	2.869
		(1.48)
	GAP45_50_1	2.427
		(0.87)
	GAP50_55_1	0.294
		(0.34)
	GAP55_60_1	6.704
		(1.94)
	GAP60_65_1	7.263
		(1.91)
	GAP65_70_1	0.060
		(0.24)
	GAP70_75_1	0.142
		(0.19)
	GAP75_80_1	0.158
		(0.16)
	GAP80_85_1	0.001
		(0.11)
	GAP85_90_1	0.000
		(0.00)
	GAP90_95_1	0.001
		(0.04)
	GAP95_100_1	9824950316.627
	NumberDays	1.011
		(5.21)**
3	Date	0.997
		(39.98)**
	IsVATincluded	1.899
		(24.08)**
	NumberBidders	0.986
		(2.81)**
	2bn.Purchase	0.731
		(13.99)**
	3.Purchase	1.199
		(7.33)**
	2bn.Region	0.610
		(22.40)**
	3.Region	1.173
		(6.01)**
	4.Region	0.928
		(3.26)**
	5.Region	0.705
		(1.16)
	BelowThresholdness	0.101
		(119.15)**
	GAP0_5_1	5.490
		(110.58)**
	GAP5_10_1	3.510
		(46.84)**
	GAP10_15_1	3.090

		(28.65)**
	GAP15_20_1	2.590
		(16.79)**
	GAP20_25_1	2.138
		(9.39)**
	GAP25_30_1	2.178
		(7.51)**
	GAP30_35_1	1.522
		(2.63)**
	GAP35_40_1	2.008
		(3.77)**
	GAP40_45_1	1.358
		(1.20)
	GAP45_50_1	1.461
		(1.19)
	GAP50_55_1	2.455
		(2.88)**
	GAP55_60_1	1.017
		(0.03)
	GAP60_65_1	1.008
		(0.01)
	GAP65_70_1	0.911
		(0.14)
	GAP70_75_1	0.597
		(0.43)
	GAP75_80_1	0.217
		(0.63)
	GAP80_85_1	0.043
		(1.19)
	GAP85_90_1	0.188
		(0.00)
	GAP90_95_1	0.001
		(0.18)
	GAP95_100_1	9.189e+41
		(0.00)
	NumberDays	1.002
		(2.58)**
4	Date	1.000
		(3.90)**
	IsVATincluded	0.946
		(4.01)**
	NumberBidders	1.485
		(190.58)**
	2bn.Purchase	0.895
		(8.69)**
	3.Purchase	0.805
		(12.20)**
	2bn.Region	0.919
		(6.25)**
	3.Region	0.960
		(2.42)*
	4.Region	0.908
		(6.77)**
	5.Region	1.320
		(1.53)
	BelowThresholdness	1.227
		(17.74)**
	GAP0_5_1	1.380

		(34.16)**
	GAP5_10_1	2.058
		(55.05)**
	GAP10_15_1	2.052
		(40.94)**
	GAP15_20_1	1.833
		(25.94)**
	GAP20_25_1	1.628
		(15.77)**
	GAP25_30_1	1.538
		(10.85)**
	GAP30_35_1	1.570
		(9.00)**
	GAP35_40_1	1.490
		(6.20)**
	GAP40_45_1	1.307
		(3.30)**
	GAP45_50_1	1.304
		(2.64)**
	GAP50_55_1	1.109
		(0.75)
	GAP55_60_1	1.331
		(1.68)
	GAP60_65_1	0.649
		(1.88)
	GAP65_70_1	0.323
		(3.65)**
	GAP70_75_1	1.003
		(0.01)
	GAP75_80_1	0.981
		(0.05)
	GAP80_85_1	0.081
		(3.79)**
	GAP85_90_1	0.000
		(0.00)
	GAP90_95_1	0.002
		(1.77)
	GAP95_100_1	4.183e+46
		(0.00)
	NumberDays	0.996
		(6.30)**
N		483,843
	* p<0.05; ** p<0.01	

Source: authors' own estimates

Table 14. GAP1 (deviation of a participant's bid as a fictitious variable in the null round (InitPricePropos) compared to an average of all participants' bids in the "blind" round), for lots with 3 and more participants

1	Date	1.000
		(2.32)*
	IsVATincluded	1.059
		(2.75)**
	NumberBidders	1.004
		(1.25)
	2bn.Purchase	1.019
		(0.97)

	3.Purchase	1.795
		(26.46)**
	2bn.Region	0.918
		(4.16)**
	3.Region	0.988
		(0.48)
	4.Region	0.877
		(6.04)**
	5.Region	1.415
		(1.30)
	BelowThresholdness	0.382
		(57.85)**
	GAP0_5_1	3.082
		(71.56)**
	GAP5_10_1	5.493
		(91.67)**
	GAP10_15_1	7.056
		(87.66)**
	GAP15_20_1	8.090
		(77.77)**
	GAP20_25_1	9.165
		(68.18)**
	GAP25_30_1	9.886
		(57.40)**
	GAP30_35_1	11.550
		(50.25)**
	GAP35_40_1	11.577
		(40.64)**
	GAP40_45_1	12.486
		(34.48)**
	GAP45_50_1	14.180
		(29.29)**
	GAP50_55_1	11.601
		(20.70)**
	GAP55_60_1	14.128
		(17.27)**
	GAP60_65_1	11.082
		(13.13)**
	GAP65_70_1	8.196
		(10.41)**
	GAP70_75_1	12.375
		(9.09)**
	GAP75_80_1	9.608
		(6.57)**
	GAP80_85_1	6.585
		(6.34)**
	GAP85_90_1	0.009
		(1.21)
	GAP90_95_1	0.302
		(0.90)
	GAP95_100_1	1.689e+30
		(71.58)**
	NumberDays	0.988
		(13.50)**
2	Date	0.998
		(3.57)**
	IsVATincluded	1.385
		(1.71)

NumberBidders	0.791
	(5.53)**
2bn.Purchase	1.193
	(1.12)
3.Purchase	1.747
	(3.13)**
2bn.Region	0.730
	(1.88)
3.Region	0.755
	(1.25)
4.Region	0.948
	(0.31)
5.Region	0.205
	(0.27)
BelowThresholdness	0.306
	(8.42)**
GAP0_5_1	2.367
	(6.47)**
GAP5_10_1	4.061
	(9.08)**
GAP10_15_1	4.163
	(7.15)**
GAP15_20_1	5.699
	(7.85)**
GAP20_25_1	6.793
	(7.43)**
GAP25_30_1	5.171
	(4.45)**
GAP30_35_1	10.321
	(6.88)**
GAP35_40_1	11.439
	(6.01)**
GAP40_45_1	5.231
	(2.29)*
GAP45_50_1	4.866
	(1.62)
GAP50_55_1	0.281
	(0.26)
GAP55_60_1	12.513
	(2.49)*
GAP60_65_1	31.262
	(4.72)**
GAP65_70_1	0.092
	(0.18)
GAP70_75_1	0.190
	(0.12)
GAP75_80_1	0.255
	(0.09)
GAP80_85_1	0.054
	(0.13)
GAP85_90_1	0.000
	(0.01)
GAP90_95_1	0.001
	(0.03)
GAP95_100_1	8.638e+27
	(6.28)**
NumberDays	0.986
	(1.85)

3	Date	0.997
		(32.15)**
	IsVATincluded	2.073
		(20.36)**
	NumberBidders	0.858
		(21.53)**
	2bn.Purchase	0.760
		(8.48)**
	3.Purchase	1.063
		(1.85)
	2bn.Region	0.630
		(16.02)**
	3.Region	1.231
		(6.01)**
	4.Region	0.884
		(4.16)**
	5.Region	0.439
		(1.52)
	BelowThresholdness	0.083
		(99.65)**
	GAP0_5_1	6.330
		(93.18)**
	GAP5_10_1	2.914
		(32.22)**
	GAP10_15_1	2.645
		(20.86)**
	GAP15_20_1	2.338
		(13.33)**
	GAP20_25_1	1.935
		(7.37)**
	GAP25_30_1	2.052
		(6.44)**
	GAP30_35_1	1.429
		(2.09)*
	GAP35_40_1	1.850
		(3.14)**
	GAP40_45_1	1.515
		(1.63)
	GAP45_50_1	1.562
		(1.37)
	GAP50_55_1	1.977
		(1.89)
	GAP55_60_1	1.319
		(0.47)
	GAP60_65_1	1.392
		(0.52)
	GAP65_70_1	0.698
		(0.44)
	GAP70_75_1	0.996
		(0.00)
	GAP75_80_1	0.515
		(0.36)
	GAP80_85_1	0.644
		(0.37)
	GAP85_90_1	0.000
		(0.06)
	GAP90_95_1	0.002
		(0.20)

	GAP95_100_1	0.000
	NumberDays	1.003
		(3.88)**
4	Date	1.000
		(1.77)
	IsVATincluded	0.945
		(3.80)**
	NumberBidders	1.190
		(80.43)**
	2bn.Purchase	0.966
		(2.43)*
	3.Purchase	0.811
		(10.67)**
	2bn.Region	0.920
		(5.69)**
	3.Region	0.984
		(0.86)
	4.Region	0.869
		(9.06)**
	5.Region	1.482
		(2.06)*
	BelowThresholdness	1.122
		(9.13)**
	GAP0_5_1	1.870
		(58.94)**
	GAP5_10_1	2.190
		(55.37)**
	GAP10_15_1	2.094
		(39.91)**
	GAP15_20_1	1.838
		(25.33)**
	GAP20_25_1	1.610
		(15.21)**
	GAP25_30_1	1.527
		(10.63)**
	GAP30_35_1	1.557
		(8.79)**
	GAP35_40_1	1.437
		(5.69)**
	GAP40_45_1	1.326
		(3.49)**
	GAP45_50_1	1.337
		(2.85)**
	GAP50_55_1	1.070
		(0.49)
	GAP55_60_1	1.427
		(2.08)*
	GAP60_65_1	0.804
		(0.96)
	GAP65_70_1	0.404
		(2.97)**
	GAP70_75_1	1.207
		(0.59)
	GAP75_80_1	0.945
		(0.14)
	GAP80_85_1	0.305
		(2.37)*
	GAP85_90_1	0.001

		(1.15)
	GAP90_95_1	0.005
		(1.44)
	GAP95_100_1	2.611e+27
	NumberDays	0.998
		(3.54)**
N		315,285
	* p<0.05; ** p<0.01	

Source: authors' own estimates

Table 15. GAP 3 (deviation of a pasticipant's bid in % in the null round compared to an expected value (ExpVal), for lots with 2 and more participants

1	Date	1.000
		(3.13)**
	IsVATincluded	1.022
		(1.28)
	NumberBidders	1.125
		(41.95)**
	2bn.Purchase	1.014
		(0.94)
	3.Purchase	1.907
		(37.19)**
	2bn.Region	0.889
		(7.22)**
	3.Region	0.907
		(4.70)**
	4.Region	0.878
		(7.52)**
	5.Region	1.342
		(1.27)
	BelowThresholdness	0.467
		(55.72)**
	GAP0_5_2	1.393
		(12.86)**
	GAP5_10_2	2.897
		(39.16)**
	GAP10_15_2	3.686
		(47.00)**
	GAP15_20_2	4.326
		(51.11)**
	GAP20_25_2	4.960
		(54.27)**
	GAP25_30_2	5.509
		(55.37)**
	GAP30_35_2	5.406
		(52.15)**
	GAP35_40_2	6.132
		(52.63)**
	GAP40_45_2	6.901
		(52.51)**
	GAP45_50_2	6.902
		(47.15)**
	GAP50_55_2	7.900
		(47.47)**
	GAP55_60_2	8.555
		(41.65)**

	GAP60_65_2	8.151
		(34.38)**
	GAP65_70_2	9.768
		(30.79)**
	GAP70_75_2	9.113
		(24.30)**
	GAP75_80_2	10.321
		(21.53)**
	GAP80_85_2	9.524
		(15.87)**
	GAP85_90_2	10.379
		(12.45)**
	GAP90_95_2	8.804
		(14.02)**
	GAP95_100_2	10.080
		(18.66)**
	NumberDays	0.985
		(19.53)**
2	Date	0.998
		(8.50)**
	IsVATincluded	1.390
		(3.27)**
	NumberBidders	0.620
		(15.67)**
	2bn.Purchase	1.292
		(3.36)**
	3.Purchase	1.097
		(0.83)
	2bn.Region	0.858
		(1.59)
	3.Region	0.865
		(1.16)
	4.Region	1.223
		(2.04)*
	5.Region	0.150
		(0.62)
	BelowThresholdness	0.453
		(11.69)**
	GAP0_5_2	1.433
		(3.26)**
	GAP5_10_2	1.703
		(4.12)**
	GAP10_15_2	2.100
		(5.46)**
	GAP15_20_2	2.294
		(5.72)**
	GAP20_25_2	1.643
		(2.84)**
	GAP25_30_2	2.299
		(4.71)**
	GAP30_35_2	2.521
		(4.94)**
	GAP35_40_2	2.981
		(5.46)**
	GAP40_45_2	2.963
		(4.73)**
	GAP45_50_2	3.508
		(5.06)**

	GAP50_55_2	2.557
		(2.88)**
	GAP55_60_2	4.198
		(4.39)**
	GAP60_65_2	4.267
		(3.82)**
	GAP65_70_2	3.339
		(2.11)*
	GAP70_75_2	4.713
		(2.72)**
	GAP75_80_2	2.243
		(0.81)
	GAP80_85_2	4.029
		(1.41)
	GAP85_90_2	0.235
		(0.30)
	GAP90_95_2	0.043
		(0.39)
	GAP95_100_2	0.920
		(0.06)
	NumberDays	1.011
		(5.22)**
3	Date	0.997
		(41.60)**
	IsVATincluded	1.931
		(24.47)**
	NumberBidders	0.910
		(17.56)**
	2bn.Purchase	0.745
		(13.14)**
	3.Purchase	1.195
		(7.23)**
	2bn.Region	0.605
		(22.91)**
	3.Region	1.211
		(7.27)**
	4.Region	0.923
		(3.55)**
	5.Region	0.686
		(1.26)
	BelowThresholdness	0.085
		(122.83)**
	GAP0_5_2	3.073
		(32.23)**
	GAP5_10_2	3.445
		(32.02)**
	GAP10_15_2	3.926
		(33.89)**
	GAP15_20_2	3.961
		(31.97)**
	GAP20_25_2	3.950
		(29.68)**
	GAP25_30_2	3.793
		(25.98)**
	GAP30_35_2	3.687
		(23.27)**
	GAP35_40_2	3.463
		(19.40)**

	GAP40_45_2	3.621
		(17.85)**
	GAP45_50_2	3.681
		(15.85)**
	GAP50_55_2	3.511
		(12.89)**
	GAP55_60_2	3.474
		(10.14)**
	GAP60_65_2	2.447
		(5.37)**
	GAP65_70_2	4.420
		(8.50)**
	GAP70_75_2	1.989
		(2.35)*
	GAP75_80_2	2.683
		(3.40)**
	GAP80_85_2	4.083
		(4.34)**
	GAP85_90_2	3.342
		(2.70)**
	GAP90_95_2	0.398
		(1.08)
	GAP95_100_2	0.530
		(1.20)
	NumberDays	1.002
		(4.12)**
4	Date	1.000
		(4.04)**
	IsVATincluded	0.934
		(4.96)**
	NumberBidders	1.445
		(178.83)**
	2bn.Purchase	0.914
		(7.03)**
	3.Purchase	0.840
		(9.81)**
	2bn.Region	0.915
		(6.65)**
	3.Region	0.958
		(2.55)*
	4.Region	0.895
		(7.78)**
	5.Region	1.359
		(1.70)
	BelowThresholdness	1.164
		(13.14)**
	GAP0_5_2	1.382
		(17.39)**
	GAP5_10_2	2.056
		(36.13)**
	GAP10_15_2	2.266
		(39.58)**
	GAP15_20_2	2.339
		(39.11)**
	GAP20_25_2	2.391
		(38.25)**
	GAP25_30_2	2.380
		(35.62)**

	GAP30_35_2	2.320
		(32.56)**
	GAP35_40_2	2.340
		(29.81)**
	GAP40_45_2	2.325
		(26.76)**
	GAP45_50_2	2.231
		(22.17)**
	GAP50_55_2	2.172
		(19.36)**
	GAP55_60_2	2.175
		(15.67)**
	GAP60_65_2	2.339
		(14.66)**
	GAP65_70_2	2.166
		(10.18)**
	GAP70_75_2	1.567
		(4.43)**
	GAP75_80_2	1.627
		(3.81)**
	GAP80_85_2	1.640
		(3.01)**
	GAP85_90_2	1.321
		(1.13)
	GAP90_95_2	0.670
		(1.49)
	GAP95_100_2	0.368
		(3.32)**
	NumberDays	0.997
		(5.40)**
N		483,843
	* p<0.05; ** p<0.01	

Source: authors' own estimates

Table 16. GAP3 (deviation of a participant's bids in % in the null round compared to an expected value (ExpVal), for lots with 3 and more participants)

1	Date	1.000
		(1.72)
	IsVATincluded	1.014
		(0.67)
	NumberBidders	0.986
		(4.11)**
	2bn.Purchase	1.032
		(1.70)
	3.Purchase	1.941
		(30.78)**
	2bn.Region	0.922
		(4.06)**
	3.Region	0.989
		(0.45)
	4.Region	0.874
		(6.37)**
	5.Region	1.579
		(1.76)
	BelowThresholdness	0.374
		(59.90)**

	GAP0_5_2	1.268
		(7.18)**
	GAP5_10_2	2.328
		(24.45)**
	GAP10_15_2	2.996
		(31.32)**
	GAP15_20_2	3.510
		(34.90)**
	GAP20_25_2	4.076
		(38.12)**
	GAP25_30_2	4.594
		(40.01)**
	GAP30_35_2	4.419
		(37.49)**
	GAP35_40_2	5.303
		(40.04)**
	GAP40_45_2	5.901
		(40.16)**
	GAP45_50_2	5.909
		(36.53)**
	GAP50_55_2	7.250
		(38.83)**
	GAP55_60_2	7.920
		(34.40)**
	GAP60_65_2	7.267
		(28.28)**
	GAP65_70_2	8.610
		(25.54)**
	GAP70_75_2	9.578
		(22.04)**
	GAP75_80_2	10.833
		(19.43)**
	GAP80_85_2	9.729
		(14.14)**
	GAP85_90_2	13.605
		(11.40)**
	GAP90_95_2	23.784
		(15.01)**
	GAP95_100_2	4.038e+30
		(0.58)
	NumberDays	0.988
		(12.74)**
2	Date	0.998
		(4.06)**
	IsVATincluded	1.540
		(2.27)*
	NumberBidders	0.783
		(6.03)**
	2bn.Purchase	1.352
		(2.06)*
	3.Purchase	1.700
		(3.00)**
	2bn.Region	0.654
		(2.67)**
	3.Region	0.705
		(1.63)
	4.Region	0.900
		(0.65)

	5.Region	0.320
		(0.25)
	BelowThresholdness	0.272
		(9.47)**
	GAP0_5_2	1.814
		(1.93)
	GAP5_10_2	2.650
		(3.01)**
	GAP10_15_2	4.095
		(4.37)**
	GAP15_20_2	3.645
		(3.83)**
	GAP20_25_2	2.905
		(2.92)**
	GAP25_30_2	4.894
		(4.49)**
	GAP30_35_2	5.275
		(4.62)**
	GAP35_40_2	8.790
		(6.17)**
	GAP40_45_2	5.275
		(3.99)**
	GAP45_50_2	9.167
		(5.57)**
	GAP50_55_2	5.578
		(3.46)**
	GAP55_60_2	10.978
		(5.01)**
	GAP60_65_2	7.067
		(3.10)**
	GAP65_70_2	3.982
		(1.36)
	GAP70_75_2	17.964
		(4.36)**
	GAP75_80_2	0.963
		(0.01)
	GAP80_85_2	29.393
		(4.32)**
	GAP85_90_2	0.918
		(0.01)
	GAP90_95_2	0.373
		(0.10)
	GAP95_100_2	1.389e+26
	NumberDays	0.985
		(1.90)
3	Date	0.997
		(37.07)**
	IsVATincluded	2.288
		(25.88)**
	NumberBidders	0.863
		(23.93)**
	2bn.Purchase	0.705
		(12.24)**
	3.Purchase	0.992
		(0.27)
	2bn.Region	0.629
		(18.00)**
	3.Region	1.317

		(8.92)**
	4.Region	0.918
		(3.23)**
	5.Region	0.360
		(2.26)*
	BelowThresholdness	0.076
		(113.37)**
	GAP0_5_2	2.557
		(22.54)**
	GAP5_10_2	2.329
		(18.60)**
	GAP10_15_2	2.609
		(20.44)**
	GAP15_20_2	2.640
		(19.59)**
	GAP20_25_2	2.666
		(18.60)**
	GAP25_30_2	2.548
		(16.29)**
	GAP30_35_2	2.518
		(14.99)**
	GAP35_40_2	2.419
		(12.81)**
	GAP40_45_2	2.721
		(13.31)**
	GAP45_50_2	2.640
		(11.26)**
	GAP50_55_2	2.678
		(9.80)**
	GAP55_60_2	2.590
		(7.44)**
	GAP60_65_2	2.255
		(5.19)**
	GAP65_70_2	3.584
		(7.29)**
	GAP70_75_2	2.007
		(2.53)*
	GAP75_80_2	2.242
		(2.70)**
	GAP80_85_2	3.150
		(3.33)**
	GAP85_90_2	3.522
		(2.44)*
	GAP90_95_2	0.425
		(0.70)
	GAP95_100_2	2.098e+27
		(0.52)
	NumberDays	1.009
		(12.49)**
4	Date	1.000
		(2.02)*
	IsVATincluded	0.946
		(3.68)**
	NumberBidders	1.172
		(73.04)**
	2bn.Purchase	0.948
		(3.73)**
	3.Purchase	0.853

	(8.01)**
2bn.Region	0.917
	(5.86)**
3.Region	0.988
	(0.66)
4.Region	0.871
	(8.87)**
5.Region	1.458
	(1.96)*
BelowThresholdness	1.076
	(5.65)**
GAP0_5_2	1.439
	(16.88)**
GAP5_10_2	2.057
	(31.58)**
GAP10_15_2	2.255
	(34.61)**
GAP15_20_2	2.325
	(34.43)**
GAP20_25_2	2.377
	(33.92)**
GAP25_30_2	2.358
	(31.79)**
GAP30_35_2	2.259
	(28.78)**
GAP35_40_2	2.295
	(26.80)**
GAP40_45_2	2.292
	(24.45)**
GAP45_50_2	2.210
	(20.63)**
GAP50_55_2	2.208
	(18.76)**
GAP55_60_2	2.242
	(15.47)**
GAP60_65_2	2.324
	(13.94)**
GAP65_70_2	2.164
	(9.87)**
GAP70_75_2	1.734
	(5.28)**
GAP75_80_2	1.753
	(4.26)**
GAP80_85_2	1.779
	(3.40)**
GAP85_90_2	1.665
	(1.90)
GAP90_95_2	1.094
	(0.28)
GAP95_100_2	5.227e+24
	(0.45)
NumberDays	0.998
	(2.52)*
N	315,285

* p<0.05; ** p<0.01

Source: authors' own estimates

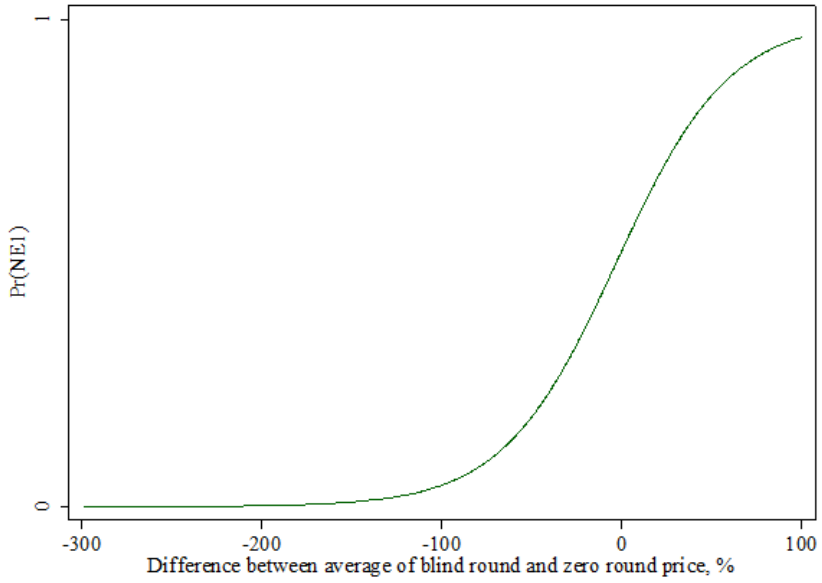

Figure 4. Deviation of a participant's bid in the null round compared to an average of participants' bids in the null round and NE1

Source: authors' own estimates

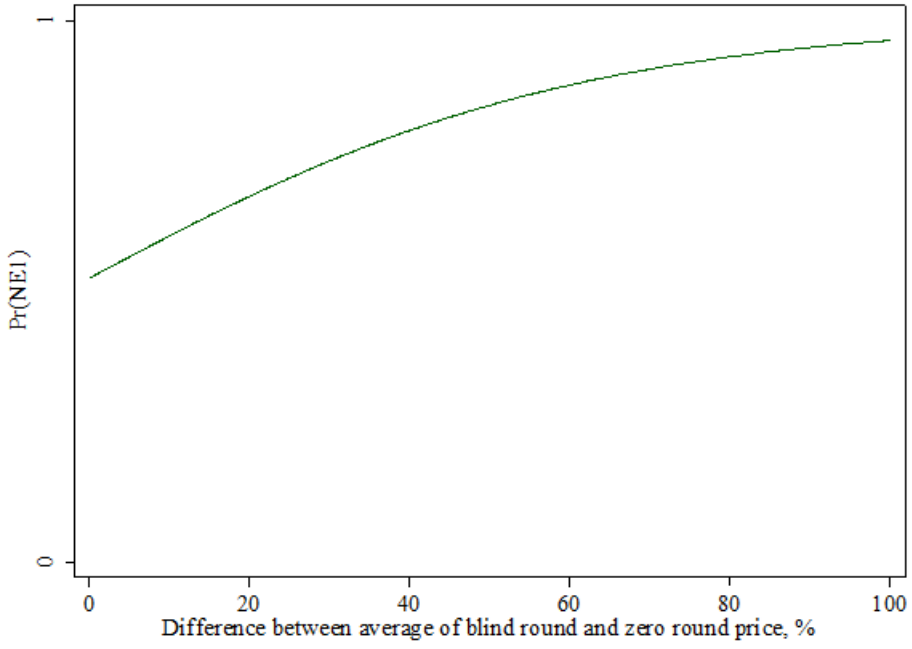

Figure 5. Deviation of a participant's bid in the null round compared to an average of participants' bids in the null round and NE1 (GAP1>0)

Source: authors' own estimates

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SCALE EFFECT AT PROZORRO PUBLIC PROCUREMENT SYSTEM: THE EXPECTED EFFECT OF CENTRALIZATION

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ABSTRACT

The centralization of public procurement can be the source of a reduction in public spending due to the scale effect. To investigate its effect in public procurement, the relationship between the volume of tender procurement and the price per unit of goods under the contract for 12 commodities of the food industry was analyzed. As a result of the research, it was discovered that an increase in purchases by centralization could reduce the price per unit when purchasing flour, beet, cabbage, potatoes, pork, onions, apples and beef, while for purchases of sugar, pasta and butter of high value the effect was not observed. This suggests that the centralization of public procurement can increase the efficiency of using budget funds, which is consistent with the objectives of the ProZorro project.

Key words: public procurement, Prozorro, scale effect, centralization

JEL classifications: D44, H57, D49

1. Introduction

Procurement of goods and services from the state budget is a significant part of Ukraine's GDP, which in 2017 reached UAH 1028.86 bln[2]. According to the Ministry of Economic Development and Trade of Ukraine (MEDT), ProZorro can achieve a 10% state saving rate due to increased competition and increased transparency of procurement procedures[3]. ProZorro is an electronic system designed to increase the transparency and efficiency of using public funds by facilitating monitoring capabilities for civil society and more competition between suppliers of goods and services. For now, one of the main directions of the MEDT's work is to increase the efficiency of public procurement. One of the promising ways to increase efficiency is the use of a centralization tool — the implementation of centralized orders for goods and

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[2] Expenditures of the State Budget of Ukraine. Resource: http://www.cost.ua/budget/expenditure/

[3] Gribanovsky, Chmil, Shapoval and others. "Is there a savings in ProZorro?" Resource:https://www.epravda.com.ua/cdn/cd1/2017/03/chy-ye-ekonomiya-v-prozorro/index.html

services, instead of separate orders by each state enterprise. The main source of economies from the centralization is the effect of economies of scale, which implies reducing the price of goods or services per unit due to increased procurement. Our task was to check if this concept works for the Ukrainian public procurement market and whether the centralization could lead to further savings in budget funds.

2. Literature review

The effect of economies of scale is the classical concept of economic theory, which is to reduce average costs per unit of output with increasing production in the short run (Lindeman, 2002[4]). The effect of this effect is also manifested in the procurement of raw materials, creating the difference between the wholesale prices at which legal entities purchase large batches of goods and retail prices in trading networks. By extrapolating the influence of this effect on public procurement of goods and services, an increase in volumes allows a significant reduction in the value of goods and a better level of service at a lower price (OECD, 2000[5]). However, in spite of the importance of this effect from the point of view of increasing the efficiency of the use of budget funds, theoretical and empirical literature devotes little attention to this issue. Scientists at the University of Perugia Luigi Albano and Marco Sparro [6] (2010) argue that increasing the cost of a contract in the event of centralization increases the market power of the customer and the attractiveness of the contract in the market, which in turn increases the number of players by reducing the price per unit. In 2012, by analyzing data on contracts for the procurement of medicines in Italian hospitals, Baldy and Vanonne[7] (2012) proved that prices for centralized purchases are significantly lower than for decentralized purchases. At the same time, they showed that in regions with higher levels of corruption, this effect is much lower. These scientific achievements indicate that centralization, related to the scale effect, is one of the main sources of increased savings in public procurement.

3. Statistical analysis

Choosing the basic analytical method, we searched for the one that would be as simple and as accurate as possible to describe the data, minimizing the sum of the squares of errors. In order to test the presence of economies of scale in the public procurement market of Ukraine, we considered the following three econometric models: the linear relationship between the price per unit of goods and the number of units in one lot, the linear relationship with the log-transformation of the main independent variable (the number of

[4] Lindeman, J. B. (2002). *Microeconomics*. Hauppauge, NY: Barron's Educational Series.
[5] Centralised and Decentralised Public Procurement. (2000). SIGMA Papers. doi:10.1787/5kml60w5dxr1-en
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[7] Baldi, S., & Vannoni, D. (2015). The impact of centralization on pharmaceutical procurement prices: the role of institutional quality and corruption. Regional Studies, 51(3), 426-438. doi:10.1080/00343404.2015.1101517

units of goods in the lot) and the dependence in which both variables (dependent - price per unit of the product and the main independent variable) are log-transformed. The main model on which our results are based is a linear model with logarithmic variables. The results of this model provide the most statistically significant coefficients and the highest determination coefficient. In addition, the distribution of values of prices and volumes of purchases is sufficiently offset, and taking logarithms can approximate the distribution to normal (in order to satisfy the assumption of the least squares method and reduce the impact of outliers).

Consequently, we simulate nonlinear relationships using logarithmic forms in a linear regression model. Therefore, our model is linear in terms of parameters and looks like this:

$$ln\, y_k = \beta_0 + \beta_{1k}\, ln\, x_{1k} + \beta_{2k} x_{2k} + \beta_{3k}\delta_{1k} + \beta_{4k}\delta_{2k} + \varepsilon_k\ ,$$

where y_k - price per unit of goods;
x_{1k} - quantity of items in the lot;
x_{2k} - number of participants (competitors) in one purchase;
δ_{1k} - a binary variable that defines the purchase with only one competitor;
δ_{2k} - a binary variable that defines the type of procurement (upstream or open bidding).
k is the product identifier. Since we analyze 12 products, $k = \overline{1;12}$.

The results of the main model and the other two are presented in the appendices.

The ProZorro database has been loaded with information about the following indices:

- price per lot,
- the number of participants,
- the number of items in the lot.

4. Conclusion

The results of the regression analysis showed that the effect of economies of scale is present in most of the markets of the studied goods. Thus, the largest decrease in the price per unit of goods is observed in the markets of onion and beet (in response to the increase in the quantity of goods in the lot by 1%, the price is reduced by 0.54% and 0.48% respectively)

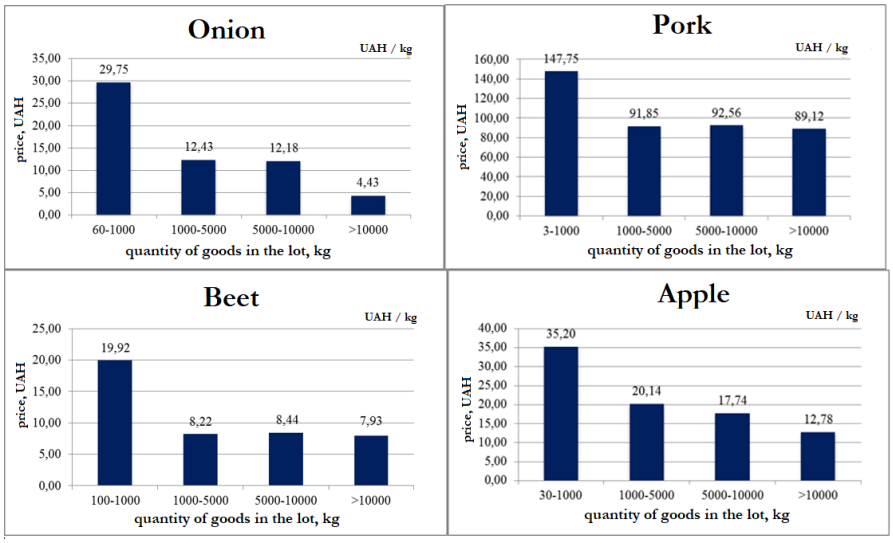

Figure 1. Price dynamics per unit of output

Source: Own calculations based on ProZorro data[8]

The presence of economies of scales with an increase in purchasing volume is also observed in the markets of such goods as beef, pork, apples, cabbage, flour, potatoes.

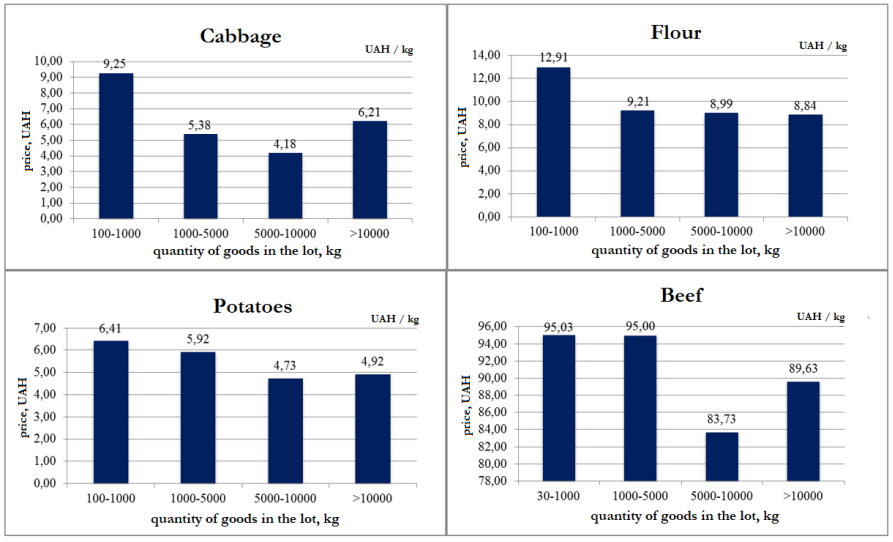

Figure 2. Dynamics of prices per unit of output

Source: Own calculations based on ProZorro data[9]

[8] https://public.api.openprocurement.org/api/0/tenders

[9] https://public.api.openprocurement.org/api/0/tenders

In the markets of butter, pasta and sugar, there is no economies of scale effect (Figure 3). At the same time, the dynamics of prices in the sugar market contradicts the classical economic theory, since with the increase in the size of a purchase the price of sugar per kilogram increases, but the influence of the amount of goods in the lot on the price per unit of goods was statistically insignificant. The current tendency in the markets for sugar and pasta may be so due to the fact that these products are products with a long shelf life. Therefore, we can assume that suppliers, expecting a decline in demand for products after large-scale purchases, increase the price per unit of output for the large volume of lots.

In turn, the behavior of prices in the market for chicken eggs is quite ambiguous (Figure 3), but the price change is insignificant, as the impact of the quantity of goods in the lot on the price per unit of goods also turned out to be statistically insignificant.

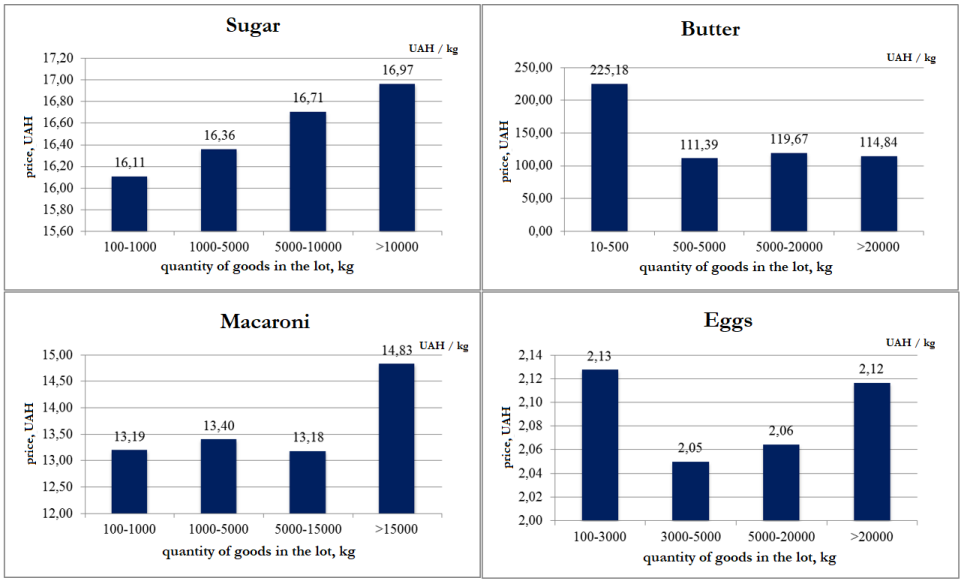

Figure 3. Dynamics of prices per unit of output

Source: Own calculations based on ProZorro data[10]

The presence of the scale effect for most of the studied goods shows that due to the centralization of procurement it will be possible to increase the economies resulting from the competitive procurement procedure. The scale effect is most significant for the purchase of beets and onions, the centralization of which is likely to lead to lower costs for public institutions. A similar situation is observed in the markets for beef, pork, apples, cabbage, flour and potatoes. At the same time, centralization is not appropriate for the procurement of sugar, butter, pasta and eggs, because there is no "economies of scale" effect for these products. Given the fact that such a situation in the markets of these goods is caused by the desire of suppliers

[10] https://public.api.openprocurement.org/api/0/tenders

to maximize their own profits, and it is quite logical from the economic point of view, the emergence of the "scale effect" for these goods is possible as the result of state interventions.

Thus, among the potential actions of state bodies there may be the direct regulation of purchases of sugar and pasta, by establishing strict control over the prices for large purchases, and direct or indirect stimulus for suppliers to reduce prices with an increase in the volume of purchases.

Thus, the presence of the scale effect in food markets indicates that it can exist in other markets, which could be a favorable area for future researches aimed at increasing the efficiency of ProZorro's operation and increasing the amount of saved public funds through this competitive platform.

Appendix A

The price per unit of goods in the lot was calculated by dividing the price of the lot by the number of items in the lot. As a result of work with data, we received 6778 observations for 12 food products (for each at least 211 observations), including pre-threshold purchases and procurement by competitive procedure from 04.2016 to 09.2017.

The results of constructing three types of regression models for each of the studied goods are given in Table 1.

Table 1. Comparing of the coefficients of 3 models of linear regression

Food products	Number of observations	Change the price per unit for each additional 1000 units	Change the price per unit for 1% increase in the number of units	Elasticity of price change from change in the number of units in a lot
Flour	261	-0.09*	-2***	-0.14***
Beet	211	-0.58*	-6.02***	-0.48***
Cabbage	283	-0.04*	-1.74	-0.24***
Potato	276	-0.01	-0.55***	-0.10***
Macaroni	691	0.03	0.02	0.0008
Butter	2093	-0.68*	-3.38*	-0.03
Pork	410	-5.79*	-107.3	-0.24***
Onion	252	-3.29***	-8.99***	-0.54***
Apples	265	-0.76	-19.46***	-0.32***
Beef	256	-0.89	-4.26**	-0.04**
Eggs	1041	0.0002	-0.03*	-0.02*
Sugar	739	0.03*	0.12	0.01

* *- the coefficient is statistically significant for a 90% confidence interval;*

** *- the coefficient is statistically significant for a 95% confidence interval;*

*** *- the coefficient is statistically significant for a 99% confidence interval;*

Source: Own calculations based on ProZorro data[11]

[11] https://public.api.openprocurement.org/api/0/tenders

Appendix B. Regression results (Stata)

Model: ln(Price)=ln(Numb)+Comp+SComp+DZ

	Борошно lPrice	Буряк lPrice	Капуста lPrice	Картопля lPrice	Макарони lPrice	Масло lPrice
lNumb	-0.136***	-0.475***	-0.240***	-0.101***	0.000763	-0.0247
	(-5.98)	(-11.58)	(-7.40)	(-5.85)	(0.11)	(-1.82)
Comp	0.0246	-0.00823	0.0229	0.00254	0.00944	0.00543
	(1.29)	(-0.22)	(0.63)	(0.13)	(1.54)	(0.89)
SComp	0.208*	-0.0338	0.0999	-0.00815	-0.0314	0.00250
	(2.55)	(-0.23)	(0.95)	(-0.13)	(-1.35)	(0.12)
DZ	-0.519***	-1.460***	-0.826***	-0.316***	-0.00975	0.233***
	(-5.16)	(-4.66)	(-6.46)	(-5.52)	(-0.19)	(-5.91)
_cons	3.614***	7.088***	4.221***	2.801***	2.555***	4.959***
	(14.77)	(14.54)	(12.32)	(14.52)	(32.97)	(46.61)
N	261	211	283	276	691	2093
R^2	0.18	0.38	0.19	0.115	0.0015	0.06

	Свинина lPrice	Цибуля lPrice	Яблука lPrice	Яловичина lPrice	Яйця lPrice	Цукор lPrice
lNumb	-0.243***	-0.540***	-0.319***	-0.0435**	-0.0154*	0.00755
	(-5.73)	(-16.07)	(-6.90)	(-2.95)	(-2.22)	(1.64)
Comp	0.0164	-0.0161	-0.0265	-0.0251	0.0248**	0.0138**
	(0.46)	(-0.41)	(-0.54)	(-1.86)	(2.66)	(3.05)
SComp	-0.159*	-0.0293	0.100	-0.120**	0.00617	-0.00848
	(-2.15)	(-0.22)	(0.86)	(-2.68)	(0.28)	(-0.68)
DZ	-0.481***	-1.309***	-1.302***	-0.105*	-0.181***	-0.0110
	(-4.74)	(-3.79)	(-5.93)	(-2.02)	(-4.51)	(-0.63)
_cons	6.554***	7.632***	6.320***	4.982***	0.969***	2.713***
	(18.82)	(17.60)	(12.02)	(35.83)	(10.24)	(54.65)
N	410	251	265	256	1041	739
R^2	0.22	0.46	0.295	0.06	0.03	0.05

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Model: Price=ln(Numb)+Comp+SComp+DZ

	Борошно Price	Буряк Price	Капуста Price	Картопля Price	Макарони Price	Масло Price
lNumb	-2.002***	-6.020***	-1.744***	-0.552***	0.0186	-3.381*
	(-4.79)	(-9.45)	(-7.10)	(-5.53)	(0.21)	(-2.36)
Comp	0.302	-0.722	0.129	-0.0398	0.106	0.306
	(1.02)	(-1.36)	(0.49)	(-0.34)	(1.33)	(0.27)
SComp	3.792**	-1.010	0.837	-0.141	-0.388	-0.198
	(2.63)	(-0.46)	(1.11)	(-0.38)	(-1.32)	(-0.07)
DZ	-6.969***	-21.26***	-4.947***	-1.502***	-0.291	-28.55***
	(-4.14)	(-4.02)	(-5.41)	(-4.72)	(-0.42)	(-4.81)
_cons	30.34***	79.81***	24.07***	11.71***	13.29***	151.5***
	(6.87)	(9.75)	(9.19)	(10.43)	(12.86)	(11.70)
N	261	211	283	276	691	2093
R^2	0.16	0.34	0.19	0.1	0.01	0.04

	Свинина lPrice	Цибуля lPrice	Яблука lPrice	Яловичина lPrice	Яйця lPrice	Цукор lPrice
lNumb	-107.3	-8.992***	-19.46***	-4.255**	-0.0299*	0.116
	(-1.55)	(-12.09)	(-4.18)	(-3.08)	(-2.22)	(1.55)
Comp	15.56	-0.890	-1.727	-2.660*	0.0498**	0.222**
	(0.97)	(-1.09)	(-0.70)	(-2.00)	(2.66)	(2.89)
SComp	-6.276	-1.781	7.674	-10.64*	0.0161	-0.119
	(-0.18)	(-0.61)	(0.97)	(-2.35)	(0.37)	(-0.58)
DZ	-205.5	-24.23**	-72.85***	-10.43	-0.365***	-0.175
	(-1.51)	(-3.17)	(-4.64)	(-1.87)	(-4.63)	(-0.61)
_cons	964.0	109.7***	235.6***	140.3***	2.602***	15.17***
	(1.79)	(11.05)	(4.90)	(10.21)	(14.20)	(18.43)
N	410	251	265	256	1041	739
R^2	0.1	0.35	0.23	0.05	0.03	0.05

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Model: Price=Numb/1000+Comp+SComp+DZ

	Борошно Price	Буряк Price	Капуста Price	Картопля Price	Макарони Price	Масло Price
Numbth	-0.0910*	-0.584*	-0.0433*	-0.0109	0.0298	-0.683*
	(-2.23)	(-2.43)	(-2.50)	(-1.39)	(1.04)	(-2.38)
Comp	0.0508	-1.835**	0.133	-0.0726	0.0989	0.121
	(0.17)	(-2.93)	(0.44)	(-0.60)	(1.25)	(0.11)
SComp	4.024**	-2.105	1.250	0.0949	-0.390	0.184
	(2.62)	(-0.82)	(1.51)	(0.25)	(-1.33)	(0.06)
DZ	-5.000*	-16.83**	-2.999***	-0.926*	-0.0359	-24.07***
	(-2.33)	(-2.80)	(-3.63)	(-2.20)	(-0.04)	(-5.56)
_cons	14.37***	36.46***	8.716***	6.561***	13.13***	128.3***
	(5.88)	(5.76)	(7.21)	(12.49)	(15.28)	(30.72)
N	261	211	283	276	691	2093
R^2	0.07	0.14	0.03	0.02	0.02	0.04
	Свинина lPrice	Цибуля lPrice	Яблука lPrice	Яловичина lPrice	Яйця lPrice	Цукор lPrice
Numbth	-5.790*	-3.292***	-0.759	-0.886	0.000136	0.0320*
	(-2.11)	(-7.07)	(-1.91)	(-1.45)	(0.87)	(2.43)
Comp	-5.475	-0.995	-1.013	-3.189*	0.0441*	0.246**
	(-0.74)	(-1.05)	(-0.45)	(-2.31)	(2.35)	(3.17)
SComp	4.984	-0.938	14.92	-10.63*	0.0141	-0.0750
	(0.12)	(-0.29)	(1.65)	(-2.33)	(0.33)	(-0.36)
DZ	-23.80	-21.58**	-46.11**	-7.102	-0.241**	0.302
	(-1.19)	(-2.65)	(-2.70)	(-1.22)	(-2.86)	(0.85)
_cons	164.1***	51.99***	68.85***	112.6***	2.223***	15.38***
	(5.49)	(6.13)	(3.70)	(13.74)	(22.87)	(33.52)
N	410	251	265	256	1041	739
R^2	0.003	0.205	0.06	0.04	0.025	0.057

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001