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RESEARCH PAPERS
IN ECONOMICS AND FINANCE

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PREFACE

Dear Readers,

I have the pleasure of presenting to you the first issue of our research journal entitled „Research Papers in Economics and Finance" (REF), published by the Faculty of Economics at Poznań University of Economics and Business. Caring about the high level of the content of our publications, we publish only the manuscripts which have received two positive reviews under the "peer review" procedure, after initial verification done by the Editorial Committee. The articles published within REF are available online in English and in an open mode.

REF focuses on two science disciplines: economics and finance. Within the former area it touches mainly upon such issues as: micro and macroeconomic policy, analysis of goals, instruments and models of socio-economic and sector policies, public sector analysis, conception of development and cyclic nature of the economy, principle of market functioning, research within the area of international economics, spatial economics, studies of the history of economic thought and the history of the economy. As regards the area of finance, we focus on such issues as: research on the phenomena and processes which take place in the economy, connected with the financial sphere, analysis of the reasons and consequences of capital flows, identifying the motifs and criteria for taking economic decisions, assessment of the investment process risk, assessment of financial markets functioning, analysis of redistribution of financial resources, taking into consideration the tax system.

REF is a quarterly journal, with the first issue containing six research articles. Let us bring you closer to the outcomes of the works presented in volume 1.

The article entitled *The Impact of Monetary Policy Announcements on Stock Market Index in Poland* by **H. Kołodziejczyk** examines whether the NBP's announcements have an impact on either stock returns or volatility and whether the content of such communiqué (either interest rate cut or raise) matters. The results suggest that, in fact, interest rate changes do have a significant impact on both returns and volatility. However, the reactions to news are different with respect to the type of announcement.

The article entitled *Exchange rate volatility and trade: the case of Ukraine* by **O. Popova**, **J. Jablinski** and **T.M. Lukashenko** concerns the subject matter of the exchange rate volatility and its influence on international trade on the basis of Ukraine. Even if there has not been any significant visible correlation between trade and the exchange rate volatility, it does not mean that there is no relationship between these two factors, because there are a lot of factors which affect the level of trade.

The article entitled *Potential fiscal and non-fiscal consequences of introducing a poll tax in Poland* by **E. Małecka-Ziembińska** and **Ł. Ziębakowski** verifies the claims made by the supporters of the introduction of a poll tax in Poland in relation to its amount. The poll tax would not gain acceptance in Poland nowadays. Potential consequences of this change must be considered not only in the fiscal, but above all – social context. The rates of the poll tax assessed on the basis of the concept of its followers are regressive. This is a disqualifying factor of this tribute, because it would bring a number of undesirable consequences to the economy and society.

The article entitled *Capital outflow in the countries exporting oil and gas as a deterrent to the economic development* by **Y.Y. Finogenova**, **D.V. Domaschenko**, **O.V. Boyko**, **V.A. Krylov**, touches upon the subject matter of capital outflows under the financial account of the trade balance in some countries exporting oil and gas. The main reasons for capital outflows lie in the specific features of the national law concerning foreign exchange as well as in the psychology of the behaviour of the economic agents carrying out activities on the territory in question. The capital outflow is caused not only by a higher exposure of business operations, corruption, weak competitiveness of the economy etc. The authors have demonstrated that the most vulnerable countries exposed to the highest level of the capital outflow risk are the countries with hybrid exchange rate regimes, in contrast to the countries adopting hard exchange rate pegs or the floating exchange rate regime.

The article entitled *Complex assessment of plant growing development in regions of Ukraine to work out recommendations for institutional changes in agriculture* by **N. Shmygol** presents the prospects and trends of crop production development in Ukraine, as well as the methods and ways of supporting this industry by the state. The author has made an appropriate ranking of Ukraine regions according to the area of sown crops in Ukraine, based on which four sectors of Ukraine areas have been allocated and grouped by crop production development level. The article goes on to give the recommendations for decision making supporting investments and state aid for each of the selected sectors to further develop crop production in the regions of Ukraine.

The article entitled *The effectiveness of using electric cars for reducing the CO2 emissions in Poland* by **M. Walkowiak** concerns the estimation of indirect CO2 emissions associated with using electric engines in Poland. The current structure of the Polish power system, which serves as the supplier of the prime mover for electric cars, uses mainly the conventional (high-emission) sources of power. Using electric cars becomes an indirect cause of the emission of pollution into the atmosphere. The author of this study compares the influence of electric cars on the environment in relation to adequate parameters which characterise cars with combustion engines. Special attention has been paid to: the specificity of the Polish system of production and distribution of energy, energy consumption and the level of emissions in the cars under analysis. The author has also presented in the article his own methodology for estimating the indirect emissions of exhaust generated by electric cars with reference to the area in which the energy is taken.

I would like to thank everyone who has been engaged in writing, editing and publishing this journal, and especially dr hab. Kamilla Marchewka – Bartkowiak, Associate Professor at UEP and the Dean of the Faculty of Economics at Poznań University of Economics and Business, for approving of this idea and supporting it actively as the Publisher. I am also very grateful to all Reviewers, who have assessed the articles in great detail, as well as to the members of the Editorial Board for their support and remarks concerning the content, the members of the Editorial Committee, without whom this and the other issues would never have been prepared. Last but not least, I would like to thank all the Authors for submitting interesting articles, their modifications following the reviews and the trust they have placed in this new journal.

We hope, as the Editorial Committee, that the articles presented in this journal will become a stimulus to creative discussions over the issues concerning contemporary economics.

Yours faithfully,

dr hab. Piotr Lis – *Editor in Chief*

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RESEARCH PAPERS
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The Impact of Monetary Policy Announcements on Stock Market Index in Poland

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ABSTRACT

Financial market participants are influenced by the news reaching them from all manner of sources, including the country's central bank. In this paper we model daily returns of WIG20 index with respect to announcements made by the National Bank of Poland (NBP) regarding the changes of the official interest rate of open market operations (the so-called reference rate) during the period of 2004-2016. The goal is to examine whether the NBP's announcements have an impact on either stock returns or volatility and whether the content of such communiqué (either interest rate cut or raise) matters. The FIGARCH model is found to be an appropriate specification for the data. Moreover, the results suggest that, in fact, interest rate changes do have a significant impact on both returns and volatility. However, the reactions to news are different with respect to the type of announcement.

Keywords: monetary policy, news effect, stock market.

1. Introduction

Ever since Fama [1970] published his findings on market efficiency, economists have started to research the topic of financial markets and the effects macroeconomic announcements have on them. Are the markets efficient? Do the prices of traded assets already reflect all previous, publicly available information? Do the prices instantly change to reflect new public information? Advances made on the field of quantitative methods, as well as rising availability of increasingly disaggregated data, have given rise to new opportunities in this field of research. This allows for creating new methods of testing how information determines asset prices.

While considering market fluctuations, one should take into account such factors as economic, political, legal, psychological, organizational or structural. The sources of public information that may influence financial markets are numerous and varying. Some of those may be: announcements of macroeconomic indicators (including the unemployment level, consumer and producer price indices, production and gross domestic product levels), statements made by politicians, heads of states, prominent figures among businessmen or economists in local or international circles, news about decisions made by state authorities or about technological advances and breakthroughs. The above list is by no means exhaustive.

This paper focuses on monetary policy announcements and their impact on the stock market. Changes in the official central bank rate of open market operations signify a more expansionary or contractionary policy which, by means of monetary transmission mechanisms, influences outcomes such as the inflation or economic output. They also help to manage the expectations of market participants through the so-called expectations channel. Market participants pay close attention to all central bank communication, especially interest rate changes, and try to anticipate those to stay ahead of the trends.

In this paper we model daily returns of WIG20 index with respect to announcements made by the National Bank of Poland (NBP) regarding the changes of the official interest rate of open market operations (the so-called reference rate). Our research covers the period from 2.1.2004 to 31.10.2016. The goal of the paper is to examine whether the NBP's announcements have an impact on either stock returns or volatility and whether the content of such communiqué (either interest rate cut or raise) matters. This paper contributes to the existing literature. We estimate univariate FIGARCH

models for the examined data. In modeling, we introduce dummy variables to control for the impact of monetary policy decisions. Therefore, we apply existing methodology to explore the reaction of Polish stock index returns to interest rate changes, which – to the best of the author's knowledge – has not been the focus of previous efforts. Additionally, the research period used in the paper is longer and more current than the periods used in other similar works focusing on the impact of interest rate changes on the Polish financial market.

The remaining part of the paper is organized as follows. Section 2 reviews the literature related to the effect of news on financial markets. Section 3 presents the methodology used for evaluating the impact of monetary policy announcements. The results are shown in Section 4. Section 5 concludes the paper.

2. Literature review

When making investment decisions, investors may be surprised by an unexpected event and modify their behaviour accordingly. Surprises are shocks for financial markets, and investors process them as information signals. Therefore, errors in predicting asset prices may be explained as an influx of unexpected news on the market. Fama's market efficiency theory [Fama 1970] has become a framework for analysing the process of price adjustments of financial instruments on the capital market and testing how information determines asset prices. On the basis of the market efficiency theory it may be assumed that new information (especially unexpected) should be reflected in the level of asset prices immediately and directly. This leads, therefore, to the study of market reactions to macro news or central bank decisions. Quantitative methods used in this field of research include event analyses, impulse response analyses, multi-equation structural macroeconomic models or vector autoregression models.

Much focus has been put on exploring the reaction of currency and capital markets to macroeconomic announcements. In the literature the impact of announcements may be observed on both returns and volatility. Macroeconomic news has been found to have a short-lived but significant effect on financial returns on the forex market [Andersen and Bollerslev 1998]. However, the influence can be more easily detected within high frequency data, and recently researchers shifted their interest to modeling the reactions in intraday data which provide more precise information for the announcement times of macro indicators.

Some of the most important works in this field include surveys made on the foreign exchange market [Goodhart 1989; Almeida, Goodhart and Payne 1998] and on equity markets [Hanousek, Kocenda and Kutan 2008]. Some studies focused on examining the impact on returns [Goodhart 1989], on volatility [Andersen and Bollerslev 1998; Andersen, Bollerslev and Diebold 2004] or on both simultaneously [Harju and Hussein 2006; Han 2007; Ehrmann et al. 2013].

The paper by Almeida, Goodhart and Payne [1998] studies a high frequency reaction of the DEM/USD exchange rate to publicly announced macroeconomic information emanating from Germany and the US. They detect a strong, quick impact of macroeconomic news, with the exchange rate reflecting the anticipated policy reaction by the monetary authorities to the piece of news. Furthermore, the impact of German announcements on the exchange rate is on average smaller than the impact of US news. In addition, they detect influences of German monetary policy decisions on the reaction of the exchange rate. Harju and Hussein [2006] examine the impact of US macro announcements on four major European equity markets. They find that US fundamentals have an impact (in both returns and volatility) on equity markets – CAC40, DAX, DMI and FTSE100. The impact of EU-wide macroeconomic news on stock market indices from Central European countries (Czechia, Poland and Hungary) is the subject of the paper by Hanousek, Kocenda and Kutan [2008]. They conclude that the reaction of emerging markets is in line with more advanced western European markets. Han [2007] uses FIGARCH models with a linearly distributed lag dummy variable to examine how US and EMU macroeconomic shocks affect high frequency Dollar-Euro returns on an intraday basis. He finds that the effects of the shocks are generally statistically significant and that they appear to be asymmetric, depending on the regions and the signs of the shocks. A recent study by Ehrmann et al. [2013] examines the determinants of the euro exchange rate during the sovereign debt crisis. While they find that exchange rate developments are difficult to explain (with macroeconomic fundamentals having low explanatory power), actions at the EU level and by the ECB have affected the exchange rate and its volatility. In particular, the ECB actions have contributed to lowering the euro's volatility.

The research into the impact of changes made to the central bank discount rate on equity market returns was pioneered by Waud [1970], Smirlock and Yawitz [1985], Pearce and Roley [1985] and Hardouvelis [1987].

In the early 1970s, Waud [1970] presented evidence that interest rates and stock prices respond to announcements of discount rate changes in the US. Smirlock and Yawitz [1985] expanded on his work by introducing 'technical' and 'nontechnical' discount rate changes, the latter containing some information about the monetary policy. In the pre-1979 period they found no evidence of announcement effects, whereas in the post-1979 period they found negative announcement effects for 'nontechnical' announcements only. Pearce and Roley [1985] similarly discovered that changes in the discount rate had a negative effect on equity prices, but only in the post-1979 period. Their paper examines the daily response of stock prices to announcements about the money supply, inflation, real economic activity, and the discount rate. The empirical results indicate that surprises related to monetary policy significantly affect stock prices, but there is only weak evidence of stock price responses to surprises beyond the announcement day. Likewise, Hardouvelis [1987] found a negative effect of discount rate changes on equity prices during the 1979-82 period, but not after 1982. His paper analyses the response of stock prices to the announcements of 15 representative macroeconomic variables. The conclusion states that stock prices respond primarily to announcements of monetary variables. While analyzing increases and decreases separately, Jensen and Johnson [1993] found effects of both 'technical' and 'nontechnical' interest rate changes, with the latter being stronger. More recent work by Jensen and Johnson [1995] included examination of periods before, during and after a discount rate change occurred. There was a negative effect on stock returns in all three periods. Thorbecke [1997] used a number of different approaches (including VAR and event study) to the relationship between the monetary policy and equity prices. He established that monetary tightening has the strongest (negative) effect on equity prices of small companies. He also concluded that expansionary policy exerts a large and statistically significant positive effect on monthly stock returns. Furthermore, he found a significant negative effect on the percentage change in the Dow Jones Industrial Average index from policy-induced changes in the federal funds rate.

Locally, the reaction of USD/PLN exchange rate to changes of the NBP reference rate was studied by Serwa and Smolińska-Skarżyńska [2004]. Basing their research on data with daily frequency from the period of 16.03.2000-31.07.2002, they have concluded that decreases of the NBP interest rate coincided with the appreciation of the Polish zloty. Gurgul [2012] has also used an event study as a method of testing the impact of different types of announcements on the Polish stock market returns. The results suggested that the first change of the NBP rediscount rate (whether up or down), reversing the previously established direction of the monetary policy (the pattern of interest rate changes), had a positive effect on stock prices. The impact of macro news announcements on intraday returns on the European stock indices has been extensively studied by Będowska-Sójka [2010; 2011; 2013]. She has established that the macro announcements from the US market have a significant impact on both returns and volatility of CAC40, DAX and WIG20 indices. However, the reactions are different with respect to the type of announcement [Będowska-Sójka 2010]. Using DAX and WIG20 she has also concluded that the domestic and neighbour-country announcements are much less important than US releases.

3. Data

The raw data set consists of daily WIG20 price quotes in the period of 2.01.2004 - 31.10.2016. WIG20 (Warszawski Indeks Giełdowy) is a Polish capitalization-weighted index quoted on the Warsaw Stock Exchange which represents 20 most liquid and biggest companies. Since the raw data (WIG20 daily closing quotations) present a non-stationary process, we use percentage logarithmic returns, calculated with the formula: r_t=100%* ln(p_t/(p_(t-1))), where p_t is a price at time t. The source for the data is www.stooq.pl database. The estimation, graphics and charts are made with OxMetrics 7.0 G@RCH 7.0 software [Laurent 2009]. The return series for WIG20 are depicted in Figure 1. The descriptive statistics for the time series are presented in Table 1.

The sample mean of the time series is not distinguishably different from zero, given the sample standard deviation. The sample skewness and the sample excess kurtosis are statistically highly significant. The empirical distribution is skewed to the left. Hence the returns are not normally distributed which is confirmed by the Jarque-Bera test. The results of the unit root ADF test confirm that the time series is stationary. In addition, with the Box-Pierce statistic we have detected autocorrelation in WIG20 returns and squared returns, and the series is characterized by the ARCH effect.

The primary instrument of the monetary policy in Poland is a short-term interest rate. The NBP reference rate determines the yield on main open market operations, affecting at the same time the level of short-term market

interest rates. The main operations currently conducted by the NBP take the form of regular issuance of the NBP money market bills, usually with a maturity of 7 days [NBP 2015]. Changes in the NBP reference rate stem from the course of the monetary policy pursued by the central bank, as determined by the Monetary Policy Council. The schedule of Council meetings is announced in advance. The source for the monetary policy announcements is the official NBP website (www.nbp.pl).

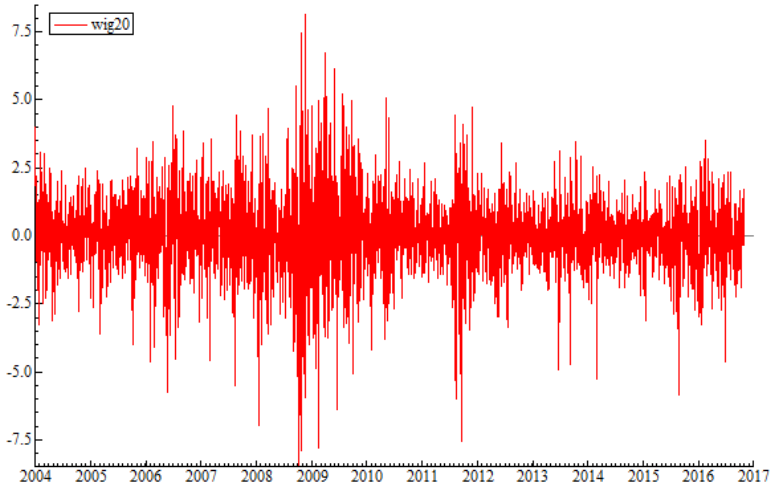

Figure 1: Daily WIG20 returns from 2.01.2004 to 31.10.2016

Table 1: Descriptive statistics of WIG20 returns in the period from 2.01.2004 to 31.10.2016

	No. of observations	Min	Mean	Max	Std. dev.	Skewness	Excess kurtosis
WIG20	3218	-8.4428	0.0036	8.1548	1.4595	-0.3012	3.2908

Between 2.01.2004 and 31.10.2016 there have been 39 changes in the official reference rate. Out of those, the Monetary Policy Council has made 16 decisions to raise the rate, and 23 decisions to cut the rate. Changes in the interest rate level tend to cluster into groups as to represent periods of expansionary and contractionary monetary policy.

The level of the reference rate and the changes made to it are depicted in Figure 2.

Out of 39 changes that were made, the interest rate was changed by 75 basis points twice, with 8 times by 50 basis points and 29 times – by 25 basis points.

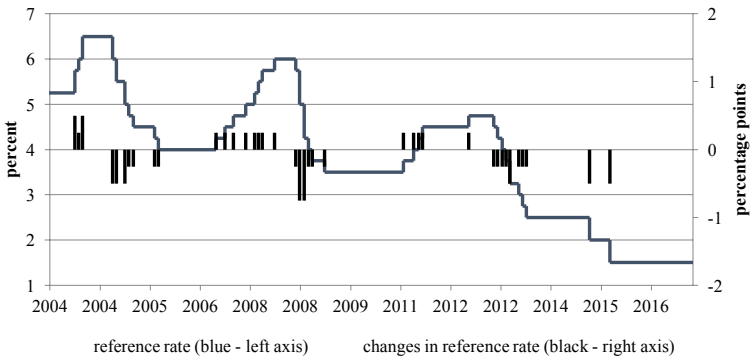

Figure 2: Reference rate level and changes from 2.01.2004 to 31.10.2016

4. Methodology

The methodology used here could be classified as following the broader meaning of an event study. Event study methodology has been introduced in the 1960s to use the financial market data to measure the impact of a specific event on the value of a company [MacKinlay 1997] by finding an abnormal return attributable to the event under analysis. It has since started to be used for examining the impact of news on prices, also implementing a variety of quantitative methods.

In the paper we use models from the ARMA and GARCH family with dummy variables added to represent monetary policy announcements taking place in the aforementioned time range. We examine if the news (of changes in the NBP reference rate) has an impact on the returns and volatilities of WIG20 index. By applying the GARCH model we are able to observe how the announcements influence the volatility of the examined series. Recently, a similar approach has been used by Będowska-Sójka [2010], Kołodziejczyk [2014], Filipowicz [2013]. All the results are generated using OxMetrics 7 with G@RCH package.

The research procedure is as follows. First, we consider the model (out of the ARMA-GARCH family) which best fits WIG20 returns. Tests are performed to confirm whether the model is well-suited to the data. Second, we create three dummy variables – one to represent information about all interest rate changes, one to account for interest rate cuts and one to account for rises. Third, the dummy variables are introduced consecutively into the conditional mean and conditional variance equations to capture the effect of the announcements on returns and volatility. The models are reestimated with the introduction of each dummy variable. The statistical significance of each estimated parameter is tested.

Some of the most important advances in modern econometrics involved modifications to the ARMA-GARCH models which allow for exploring both linear (autocorrelation in returns) and nonlinear (autocorrelation in squared returns) properties found in the data. ARMA is used to model a conditional average in the series. ARCH (autoregressive conditional heteroskedasticity) is a time series regression model of the volatility of a financial time series developed by Engle [1982]. A useful generalization of this model is the GARCH model introduced by Bollerslev [1986]. The conditional mean and conditional variance equations for ARMA(r,s)-GARCH(p,q) are:

$$r_t = \mu_t + y_t$$
$$\mu_t = a_0 + \sum_{i=1}^{r} a_i r_{t-i} - \sum_{j=1}^{s} b_j y_{t-j}$$
$$y_t = \sigma_t \varepsilon_t$$
$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i y_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$$

where ε_t ~ iid(0,1), ω > 0, α_i ≥ 0 and β_j ≥ 0.

In the conditional variance equation alpha parameters account for shocks in squared returns, whereas the beta parameters represent a weighted average of past squared returns. Apart from a Gaussian distribution, εt may also be modeled with other distributions: Student's t, skewed Student or GED distribution to account for the fat tails of the high-frequency or skewed financial time-series. Additional variables can be added to the conditional mean and variance equations.

Due to the long memory in the series of absolute returns we chose the FIGARCH model out of the GARCH family of models – the choice was made on the basis of information criteria and the statistical significance of parameters. FIGARCH (p,d,q) specification was introduced by Baillie, Bollerslev and Mikkelsen [1996] and is known as the BBM's method. The conditional variance can be specified as:

$$(1 - \beta(L))\sigma_t^2 = \omega + [1 - \beta(L) - \phi(L)(1 - L)^d]y_t^2$$

where lag polynomials are:

$$\beta(L) \equiv \beta_1 + \cdots + \beta_p L^p, \phi(L) \equiv 1 - \phi_1 L - \ldots - \phi_q L^q,$$

and 0≤d≤1 being the fractional differencing parameter. When d=0, then FIGARCH reduces to the standard GARCH model. When d=1, then FIGARCH becomes the IGARCH (integrated GARCH) model, implying the complete persistence of the conditional variance to a shock in squared returns.

The exact specification of an ARMA(1,1)-FIGARCH(1,d,1) conditional mean and variance equations used in this paper is as follows:

$$r_t - \mu = a_1(r_{t-1} - \mu) + (-b_1)y_{t-1} + y_t$$
$$y_t = \sigma_t \varepsilon_t$$
$$\sigma_t^2 = \omega + \beta_1 \sigma_{t-1}^2 + [1 - \beta_1 L - \phi_1 L(1 - L)^d]y_t^2$$

Subsequently, we introduce dummy variables x_(i,t) into both conditional mean and conditional variance equations:

$$r_t\text{-}(\mu + \sum_{i=1}^{k} c_i x_{i,t}) = a_1 \left(r_{t\text{-}1}\text{-}(\mu + \sum_{i=1}^{k} c_i x_{i,t\text{-}1}) \right) + (\text{-}b_1) y_{t\text{-}1} + y_t$$

$$y_t = \sigma_t \varepsilon_t$$

$$\sigma_t^2 = \omega + \beta_1 \sigma_{t\text{-}1}^2 + \sum_{i=1}^{k} \omega_i x_{i,t} + [1 - \beta_1 L\text{-}\phi_1 L(1-L)^d] y_t^2$$

These dummy variables are defined in the way that they take the value of 1 only at the time of the monetary announcement (for the return on the day of the interest rate change) and 0 otherwise. To facilitate the examination of the interest rate changes in general, as well as cuts and rises in the rate separately, three dummy variables are introduced:

- CHANGE – which takes the value of 1 each time the reference rate has been changed by the monetary policy committee of the NBP (39 decisions),
- UP – which takes the value of 1 each time the reference rate has been raised by the monetary policy committee (16 decisions),
- DOWN – which takes the value of 1 each time the reference rate has been cut by the monetary policy committee (23 decisions).

In the end, the statistical significance of each estimated parameter is examined in order to judge which factors have a significant influence over the returns on WIG20 and their volatility.

5. Results

Table 2 presents the estimation results of applying the model without any announcement dummies to the WIG20 returns in the first step of the procedure.

Table 2: The estimates of ARMA(1,1)-FIGARCH(1,d,1) without dummy variables

parameters	base model for WIG20
a_1	**-0.274802** (0.10829)
$-b_1$	**0.306071** (0.11835)
ω	**0.023129** (0.00906)
d	**0.608340** (0.07925)
ϕ_1	**0.185745** (0.04656)
β_1	**0.773117** (0.04463)
Asymmetry ln(ξ)	**-0.057797** (0.02194)
DF (ν)	**8.475866** (1.2262)
Log likelihood	-5350.607

Note: Estimated parameters together with standard errors (in parentheses) are reported. The bolded parameters are statistically significant at α=0.05. Skewed Student distribution was used with DF (degrees of freedom) and asymmetry coefficient reported.

As can be seen in Table 2, parameters in the conditional mean equation, both the autoregressive and moving average component, are statistically significant. In the conditional variance equation ω, ϕ, β and d are significant and the values are reasonable. It suggests that volatility is impacted by both persistence (represented by parameter β) and squares of previous shocks (represented by parameter ϕ). The long memory volatility parameter (d) is estimated to be 0,6 and appear to be statistically significant. Thus, the hypotheses that d=0 (stationary GARCH) and d=1 (integrated GARCH) can be rejected for the WIG20 returns. Furthermore, a series of diagnostic tests on the standardized residuals and squared standardized residuals failed to detect any need to further complicate the model . In that regard daily WIG20 returns seem to be similar to high frequency data, since related research suggests that high frequency (from 5 min to 30 min) data also have a long memory property in the volatility process [Han 2008, Będowska-Sójka 2011]. The estimated number of degrees of freedom in regards to Student's t-distribution is relatively high, meaning it is more similar to the normal distribution, and therefore contains less outliers (the tails are less heavy).

The estimated effects of monetary policy announcements on the conditional mean and conditional variance of the WIG20 returns are reported in Table 3 and 4. The estimation results show that the estimated parameters of models with dummy variables are generally quite similar to those of the base model reported in Table 2. In particular, the estimated value of long memory parameter of models (1), (2) and (3) is found to be almost the same as that estimated form the base model in Table 2. Apart from the dummy variable, all other parameters are still statistically significant. When examining the reaction to all NBP announcements of interest rate changes (represented in the dummy variable CHANGE) it seems that those announcements are not statistically significant to the model. The CHANGE variable was not significant, either added to the conditional mean equation (2), to the conditional variance equation (3), or to both of them (1). However, what is worth noting is that the value of the logarithm of the likelihood function for the model with announ-

cement dummies (in both equations – model (1)) is noticeably higher than without them (base model). It suggests that the news of reference rate changes is important in explaining the behaviour of returns and volatility.

Table 3: The estimates of ARMA(1,1)-FIGARCH(1, *d*, 1) with dummy variable CHANGE

parameters	(1)	(2)	(3)
	conditional mean equation		
a_1	**-0.289365** (0.11072)	**-0.281402** (0.10884)	**-0.278681** (0.10961)
$-b_1$	**0.323130** (0.12039)	**0.314370** (0.11846)	**0.310195** (0.11978)
CHANGE	0.268939 (0.15690)	0.247982 (0.15143)	
	conditional variance equation		
ω	**0.026781** (0.00966)	**0.023002** (0.00903)	**0.025883** (0.00944)
d	**0.604769** (0.08168)	**0.608060** (0.07880)	**0.610126** (0.08243)
ϕ_1	**0.186055** (0.04770)	**0.185041** (0.04649)	**0.185237** (0.04813)
β_1	**0.771159** (0.04595)	**0.772632** (0.04429)	0.774653 (0.04600)
CHANGE	-0.236667 (0.12508)		**-0.180560** (0.12031)
Asymmetry ln(ξ)	**-0.056710** (0.02192)	**-0.056403** (0.02190)	**-0.057475** (0.02198)
DF (ν)	**8.581282** (1.2665)	**8.490878** (1.2279)	**8.532061** (1.2508)
Log likelihood	-5348.52	-5349.51	-5350

Note: Estimated parameters together with standard errors (in parentheses) are reported. The bolded parameters are statistically significant at α=0.05. Skewed Student distribution was used with DF (degrees of freedom) and asymmetry coefficient reported. Numbers correspond to models: (1) dummy added to both equations; (2) dummy added to conditional mean equation; (3) dummy added to conditional variance equation.

Table 4 presents the results of estimated models with separate dummies for reference rate cuts and raises. Once more, the estimates of models with and without announcement dummies are quite similar. The introduction of two dummies into the base model (into both equations) results in increasing the value of logarithm of likelihood function, which suggests that news of monetary decisions give additional information when modeling daily WIG20 returns. In fact, model (4) has the highest log likelihood of all considered models. However, not all dummy variables are statistically significant. When adding dummies UP and DOWN into the mean and variance equation separately it becomes clear that the effect is created either when the DOWN dummy is inserted into the conditional mean equation (6) or when the UP dummy is inserted into the conditional variance equation (8). After excluding variables without statistical significance form model (4), model (9) has been reached as a consensus. The news of a decrease in the NBP reference rate impacts the market by increasing the level of market returns. The overall coefficient has a positive value of 0.14 . On the other hand, when we consider the dummy standing for reference rate increases it is visible that in Poland such announcements decrease volatility notably. Monetary decisions to the contrary have no statistical significance in regard to market volatility. It is in line with earlier findings by Filipowicz [2013].

Finally, both conditional mean and conditional variance estimations from model (9) are presented in Figure 3. The dynamic of conditional variance clearly shows the period of increased volatility during the global finance crisis present in the sample.

Table 4: The estimates of ARMA(1,1)-FIGARCH(1, *d* ,1) with dummy variables UP and DOWN

parameters	(4)	(5)	(6)	(7)	(8)	(9)
	conditional mean equation					
a_1	**-0.290574** (0.11023)	**-0.272962** (0.10800)	**-0.282217** (0.10851)	**-0.283044** (0.10897)	**-0.275008** (0.10843)	**-0.290337** (0.10899)
$-b_1$	**0.324072** (0.11993)	**0.303777** (0.11820)	**0.315504** (0.11798)	**0.315371** (0.11892)	**0.306280** (0.11851)	**0.324682** (0.11835)
UP	-0.196209 (0.28952)	-0.154648 (0.22373)				
DOWN	**0.483366** (0.16175)		**0.474200** (0.16562)			**0.474717** (0.16479)
	conditional variance equation					
ω	**0.027906** (0.01016)	**0.023114** (0.00906)	**0.022889** (0.00899)	**0.025404** (0.00920)	**0.023377** (0.00934)	**0.025166** (0.00914)
d	**0.605573** (0.08341)	**0.609204** (0.07940)	**0.610388** (0.07885)	**0.608406** (0.08283)	**0.608278** (0.07940)	**0.610130** (0.08226)
ϕ_1	**0.182190** (0.04796)	**0.185394** (0.04660)	**0.183326** (0.04656)	**0.184246** (0.04832)	**0.185826** (0.04665)	**0.181944** (0.04823)
β_1	**0.770160** (0.04805)	0.773652 (0.04469)	**0.773663** (0.04420)	**0.773195** (0.04643)	**0.773126** (0.04469)	**0.773535** (0.04596)
UP	**-0.540273** (0.27541)			-0.464179 (0.13372)		**-0.463285** (0.13355)
DOWN	-0.191659 (0.20293)				-0.023880 (0.16437)	
Asym ln(ξ)	**-0.055658** (0.02176)	**-0.058272** (0.02192)	**-0.054958** (0.02177)	**-0.058252** (0.02200)	**-0.057747** (0.02193)	**-0.055383** (0.02182)
DF (ν)	**8.507569** (1.2497)	**8.454288** (1.2230)	**8.440996** (1.2171)	**8.573899** (1.2597)	**8.479928** (1.2304)	**8.539870** (1.2514)
Log likelihood	-5345.465	-5350.44	-5347.96	-5348.87	-5350.6	-5346.24

Note: Estimated parameters together with standard errors (in parentheses) are reported. The bolded parameters are statistically significant at α=0.05. Skewed Student distribution was used with DF (degrees of freedom) and asymmetry coefficient reported. Numbers correspond to models: (4) dummies UP and DOWN added to both equations; (5) dummy UP added to conditional mean equation; (6). dummy DOWN added to conditional mean equation; (7) dummy UP added to conditional variance equation; (8) dummy DOWN added to conditional variance equation; (9) dummy DOWN added to conditional mean equation and dummy UP added to conditional variance equation.

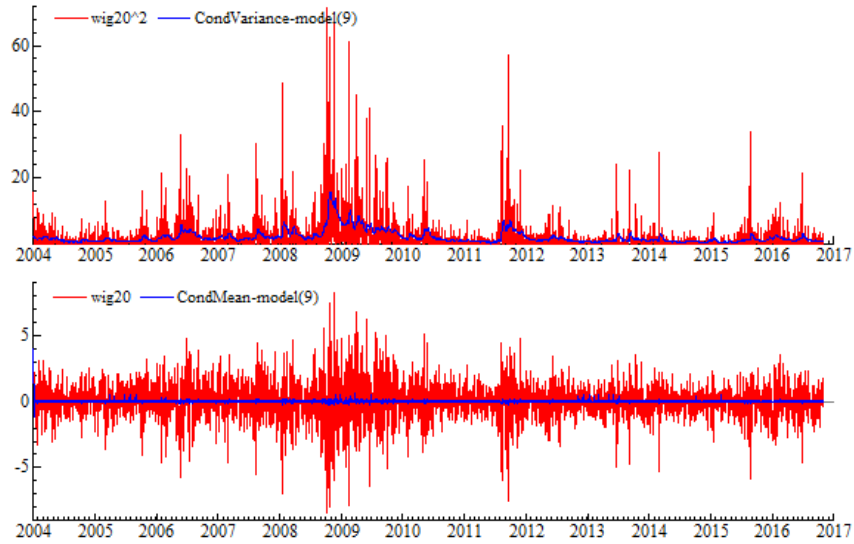

Figure 3: Estimation of conditional mean and variance from model (9) as well as actual WIG20 returns and squared returns

6. Concluding remarks

This paper provides a characterization of daily WIG20 returns on the Polish market from 2004 to 2016. We find that the volatility process of the time series is well described by the FIGARCH process. The estimate of the long memory parameter is found to be statistically significant, implying that in that regard daily WIG20 returns are similar to high frequency data.

We also provide a quantitative analysis of the impact of shocks on both the conditional mean and conditional variance – using the daily data of WIG20 combined with Polish monetary announcements (of changes in the reference rate), we examine the impact of news on returns and volatility of this index. In particular, this paper investigates how the effects vary depending on whether the change in the reference rate was an increase or a decrease.

This study shows several important results. First, adding dummy variables representing changes of the interest rate to the conditional mean and variance equations increases the logarithm value of the likelihood function. In fact, it is highest for the model with two separate dummy variables representing cuts and raises. This result confirms that news such as monetary announcements can be used as a factor relevant to explaining the behaviour of returns and volatility. Second, WIG20 quotes respond asymmetrically depending on the exact nature of the interest rate change – whether it is a cut or a raise. Interest rate cuts have an effect by increasing the level of market returns, but are not significant in regard to volatility, whereas reference rate raises impact the market by decreasing volatility, but have no significant effect on market returns. This observed decrease in volatility may be due to a calming effect on the market established by confirming the expectations of market participants (expectations are represented in the level of stock index in advance of the announcement). It may also be due to central bank's communication strategy being able to dispel any doubts felt by investors on the stock market.

A logical step forward in this field of research is to examine the impact of monetary announcements on high-frequency data as well as on prices of other types of assets.

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Exchange rate volatility and trade: the case of Ukraine

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ABSTRACT

This article demonstrates the assumptions of economic theory and its followers, the theories which stimulate research on the positive correlation between the success of the economy, its growth and the level of international trade. The empirical analysis of this paper examines the example of the exchange rate volatility and its influence on international trade on the basis of Ukraine. In the descriptive part of this study, which looks at the exchange rate volatility in Ukraine as a whole, the authors have aggregated the bilateral volatilities using trade shares as weights to obtain what is referred to as the "effective volatility" of the country's exchange rates. It is summarized that the current situation in Ukraine is extremely difficult, and external financial support could alleviate the crisis. The time span used in the work includes the years from 1999 to 2014, with the help of which the authors have demonstrated the fluctuation and correlation between these two factors. From the graph it has been possible to make the conclusion that even if there was no significant visible correlation between trade and the exchange rate volatility, it does not mean that there is no relationship between these two factors, because there are a lot of factors which affect the level of trade.

Keywords: volatility; trade; exchange rate; transitional economies; international transactions.

1. Introduction

Currently the most traditional and the most advanced form of international economic relations is the international trade, which accounts for about 80 percent of the total volume of international economic relations. Today, international trade is the most important form of communication between producers from different countries, based on the emerging international division of labor, which expresses their mutual economic dependence, as well as the process of buying and selling which takes place between buyers, sellers and intermediaries in different countries. As a result, countries sign new economic agreements and conclude contracts. A relevant question which arises at this point refers to the analysis of a number of such criteria as the exchange rate volatility, different factors and indication of economic development.

For every country, the role of foreign trade is difficult to overestimate, as the economic success of any country in the world depends nowadays on foreign trade. Yet no country has managed to create a healthy economy, isolated from the world economic system and trade.

The authors of this paper examine in particular such criteria as the exchange rate volatility and consider the presence of correlation with international trade. The study demonstrates the assumptions of economic theory and its followers, the theories which push forward to research the positive correlation between the success of the economy, its growth and the level of international trade. The consequences of the growth in the level of international trade and its effect on the division of revenue are not too visible. International trade, even being affected by different factors, shall have all intents and purposes to lead to a growth in the economy and the development of an economic system in the general and the overall welfare of a community.

In spite of the fact that there is much research and a number of theories, analyses and assumptions about the influence of the exchange rate volatility on the international trade, there is no prevailing convention about the value and heading of this influence. The indeterminacy of the empirical analysis might be the consequence of accepted complexities which are connected with modeling in econometrics. One of the problems could be caused by an indeterminate variable which is not included in the econometric modeling, and it is very frequent when they are not correlated with other illustrated variables. The next problem might be

caused by at least one or more undetermined variables which are not included in the econometric modeling. Also, the last issue is based on the correct form of the function of the correlations which are not known.

The empirical analysis of this paper examines the example the exchange rate volatility and its influence international trade on the basis of Ukraine. The time span used in the work includes the years from 1999 to 2014, with the help of which the authors have made a graph and demonstrated the fluctuation and correlation between these two factors. Thus, this paper seeks to investigate the presumptive effect of the exchange rate volatility on the international trade. The content of this paper is organized as follows: chapter one presents theoretical approaches by the traditional school, the risk portfolio school and some alternatives with their corresponding supporters. Chapter two examines the empirical analysis, where the description of the nominal exchange rate versus the real exchange rate is given. The authors subsequently suggest measuring the volatility, whereas in the last subchapter they demonstrate the empirical results of the relationship between the exchange rate volatility and trade by different scientists and authors. Chapter three proposes a significant example of the Ukrainian situation concerning its exchange rate volatility and its correlation with trade. Finally, the summary is given in the conclusion.

2. Analysis of recent research and publications

This paper reviews the literature that focuses on a variety of opinions which include Higgins, Klitgaard [2014], Porter [1990], Tenreyro [2007], Tielens, Van Aarle, Van Hove [2014]. The arguments presented in the paper suggest that the information within and across different studies can tell us a lot about a wide range of facts related to trade competitiveness and factors that force its movements. For instance, Porter [1990] in his work affirms that the competitive advantage of a country can be in terms of new technologies. As pointed out by Grilo and Koopman [2006], through its microeconomic factors (the same as a growth in international trade, an increase in productivity and labor cost), a country can improve the competitiveness aggregate. Belke, Schnabl, Zemanek, [2013] in their paper determined the following price and non-price indicators of an export growth: productivity efficiency; exchange rate; export to import ratio; price elasticity of export; technological innovations and specialization.

All the above mentioned opinions and studies were really substantial and informative; however, there is a lack of detailed economic and mathematical tools in an approach to the analysis of the exchange rate volatility and its impact on trade.

The purpose of the article is to research the dynamics of the exchange rate in Ukraine with the help of economic and mathematical tools in order to make visible some kinds of regularities, to realize future forecasts intentionally, to minimize losses and to ensure profitability of transactions, as well as to analyze such factors as export and import which are under the influence of the exchange rate in different economical periods.

3. The main material

A great deal of literature has been dedicated to this issue so far and there is still no consensus on the appropriate method for measuring the exchange rate volatility. The lack of agreements is the result of a number of factors. There is no generally accepted model of firm behavior that is subject to risk arising from fluctuations in exchange rates and other variables. As a result, theory cannot provide the definitive guidance to which measure it is more proper. Furthermore, the scope of the analysis will dictate to some extend the type of measure used. If advanced countries are surveyed, we should take into account the effect of forward markets for the assessment of the exchange rate volatility on trade, whereas this will not be possible if we extend our analysis also to a larger number of developing countries. Another feature of the exchange rate volatility that needs to be taken into account is the time horizon over which the variability is measured, as well as whether it is unconditional volatility or rather the unexpected movement in the exchange rate relative to its predicted value that is the relevant measure.

Finally, the level of aggregation of trade flows under analysis also plays a role in determining the most suitable measure of the exchange rate which is going to be used. Methodologically, the basic building block in the analysis is the volatility in the exchange rate between the currencies of each pair of countries in the sample, because it allows for the best control over a variety of factors other than volatility that could affect the trade. As a result, the change in detecting an impact of the exchange rate volatility on trade improves. The most significant question in the process of trade appears to be about the effect and influence of the exchange rate and the approaches in determining the measure of the exchange rate volatility. Côté lists

several of the most important considerations, including "…whether it should be bilateral or effective, real or nominal, and the appropriate way of measuring risk: short-run versus long--run horizon, ex ante versus export, sustained deviations from trend versus period-to-period movements."

There are two ways to measure the volatility of the exchange rate. In the first approach it is applicable to use the excess between the future exchange rate and the present-day exchange rate. The second approach consists in determining the standard deviation or it might be a variance of the degree of the exchange rate which must be either nominal or real. Unfortunately, there was no found approach for measuring the volatility of the exchange rate and the proclivity for the exchange rate to own the distorted volatility grouping, which was used in order to confute the simple method of theoretical statistical data for measuring the volatility of the exchange rate. Characteristic propensities of the statistical data referred to the financial temporal series, which are considered in the following part of the work.

It is very important to mention that a number of empirical analyses have highlighted the significance of decision making in the most effective measuring of the exchange rate volatility, not including the first designation of the differential between the two factors, i.e. between the expected and unexpected volatility. If we assume the parallel to the theory of the consumer, it is known that the expectations of consumers are an immaterial point, and that is why it has been confirmed in the case of trade on the international level, that the expectations of economic agents concerning the exchange rate volatility are the consequences which are expressed in the effect on the levels of international trade. Many scientists, including Farrell, have pointed out and highlighted the difference between the indeterminate and systematic movements of the exchange rate. If the traders could make a plan or forecast systematic alterations, the changes which are in reality indeterminate changes in a lot of cases, would designate the moves and shifts generated by the exchange rate volatility. Consequently, the majority of literature focuses not just on the way of measuring the volatility of the exchange rate but also on the way of predictive modeling.

For the descriptive part of this study, which looks at the general exchange rate volatility in Ukraine, it is necessary to aggregate bilateral volatilities, using trade shares as weights, to obtain what is referred to as the "effective volatility" of the country's exchange rates. This ensures that the measures of volatility in the descriptive and econometric parts of the study are fully consistent. Such a measure of effective volatility presupposes that the exchange rate which an individual firm faces is the average of the variability of individual bilateral exchange rates [Lanyi, Suss, 1982]. However, if a trading firm engages in international transactions with a wide range of countries, any tendency for exchange rates are moved in opposite directions to offset the overall exposure of the firm to the exchange rate risk. This would justify the use of the volatility of the country's effective exchange rate as the measure of an exchange rate which the country faces. This method seems to be particularly suitable for developed economies, where most trade is undertaken by multinational corporations. It is also important to realize that the degree of the exchange rate variability to which a country is exposed, is not necessarily closely related to the type of an exchange rate regime, to which it has adapted. A country may peg its currency to an anchor currency but will float against the other currencies if the anchor does as well. Therefore, effective volatility means the same multidimensional concept as an effective exchange rate [Polak, 2002]. Pegging can reduce the nominal exchange rate volatility vis-à-vis one trading partner, but it can by no means eliminate the overall exchange rate variability.

This paper demonstrates the exchange rate volatility and its indicators of trade on the example of Ukraine. Concerning the current economic crises in Ukraine, the exchange rate is not stabilized. First of all, it is crucial to mention that the foreign exchange rates and currency parities are integral elements of the international monetary and financial system. Nowadays the monetary and financial systems in Ukraine are weakening. There is the multiplicity of factors that affect exchange rates, causing their fluctuations, which have a great influence on the activities (in particular an activity of trade) of foreign and domestic firms and companies. For example, a decrease in the exchange rate leads to the fact that the exporters in the exchange of profit in foreign currency during proceeding into the national currency start getting more profitability than before. Taking this into account, exporters are able to reduce the prices of their products on the global market, denominated in the foreign currency. This strengthens the competitiveness of the products on the global market, and thus contributes to the export of goods and services. Thus, there are numerous nuances which have an influence on the level of trade, including the country's level of government regulation and support of foreign currency. The following section examines the

currency exchange rate, annually over the time span encompassing the years from 1999 to 2014. Subsequently, the authors show the flow exports measured in US Dollars at current prices and current exchange rates in millions, the same as flow imports measured in US Dollars at current prices and current exchange rates in millions. Next, the authors analyze the net export, calculate the coefficients of net export, and finally, they demonstrate a graph which reflects the situation concerning the exchange rate volatility and trade in Ukraine.

Table 1: Currency Exchange Rate, annual 1999-2014

Years	Exchange rate of Hryvna to 1 USD
1999	4.1304
2000	5.4402
2001	5.3722
2002	5.3266
2003	5.3327
2004	5.3192
2005	5.1247
2006	5.0500
2007	5.0500
2008	5.2672
2009	7.7912
2010	7.9356
2011	7.9676
2012	7.9910
2013	7.9930
2014	11.9000

Note: The exchange rate ratio 1 dollar to the corresponding hryvna equivalent.
Source: (adapted from) http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=entt.

For the first step, there is a table below which describes the exchange rate of 1 dollar US to Hryvna.

On the basis of the above table it may be noted that from the year 2000 the exchange rate changed from 4.1304 Hryvna to 5.4402 Hryvna, after which there was stabilization of the currency. From 2009 the exchange rate increased from 5.2672 Hryvna to 7.7912 Hryvna. In 2014 year there was the highest level of the exchange rate, which amounted to 11.9 Hryvna.

For a better demonstration, in the following graph (below) of the correlation between the exchange rate volatility and trade it seemed necessary to provide the balanced coefficients (from amount of Hryvnas in 1 USD) (to make all the values in the common unit of measurement).

The following formula will help in realizing the growth rate:

(A2-A1)/A1, where A1 – the previous year, A2 – the following year.

For the next step it is reasonable to demonstrate the trade indicators of export and import in Ukraine.

Table 2: Coefficient of Exchange Rate (fluctuations) and Flow Exports Measure

Years	Coefficient	Value of export, million US Dollar
1999	-	11582.0
2000	0.3171	14572.5
2001	-0.0125	16265.0
2002	-0.0085	17957.0
2003	0.0011	23066.8
2004	-0.0025	3266.1
2005	-0.0370	34228.4
2006	-0.0150	38368.0
2007	0.0000	49296.1
2008	0.0430	66954.4
2009	0.4792	39782.0
2010	0.0185	51478.0
2011	0.0040	68460.0
2012	0.00294	68530.0
2013	0.0003	64338.0
2014	0.4888	54199.0

Note: US Dollars at current prices and current exchange rates in millions

Source: (adapted from) http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=entt.

On the basis of the above table it is noticeable that the greatest value of export in millions US dollars during the last 16 years was marked in the year 2012, with 68530 million dollar US, after which the value of export started to decrease and reached 54199 million US dollars in 2014 year. Thus, it is visible that it was running low to the similar level of value as in the year 2010 where it was 51478 million US dollars.

The table below represents the values of flow imports measured in US Dollars at current prices and current exchange rates in millions in Ukraine.

Table 3: Flow Imports Measure

Years	Value of import, millions US Dollar
1999	11846
2000	13956
2001	15775
2002	16977
2003	23020.1
2004	28996.8
2005	36136.3
2006	45038.6
2007	60618
2008	85535.3
2009	45487
2010	60911
2011	82594
2012	84639
2013	76787
2014	54330

Note: US Dollars at current prices and current exchange rates in millions
Source: (adapted from) http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=entt.

This table gives a view of the levels of value of import in Ukraine, with the lowest level of import falling on the year 1999 with the value 11846 million US Dollars, after which there was an observable increase in values of import. However, this tendency was just prior to 2009, with the value of 45487 million US Dollars. After 2009 there was a growth in the value of import but until 2013, after which there occurred a decrease and by 2014 it reached 54330 million US Dollars.

On the basis of the above mentioned, collected data the authors present the fluctuations of the exchange rate and growth rate of sum of exports and imports divided by the GDP values (Fig. 1).

Similarly to the previous graph, there is quite a similar situation here, with a relatively stable level of growth in the exchange rate from about 2000 to 2005. However, taking into consideration the historical background, it is possible to observe that at this time the so-called "stabilization" was made artificially by the National Bank of Ukraine, and consequently, there occurred a situation which was very similar to a "credit soap bubble". As a result of its collapse in 2007, the accumulation of negative tendencies in the economy could be observed, which was expressed in the rapid decrease in the exchange rate growth. In 2008 – 2009 the growth in the exchange rate started increasing and reached 0.4792 (however on this graph it is impossible to evaluate the tendency of the sum of exports and imports divided by the value of the GDP (trade openness ratio) to see if it is positive or negative, in comparison with the other version of the calculations and defining of the correlation).

From these three graphs, which include different variables, it is possible to make the conclusion that if there is no determinant, visible correlation between trade and exchange rate volatility it does not mean that there is no relationship between these two factors. First of all, it is explained by a variety of causes which influence the exchange rate, and as a result influence the indicators of trade. Among the variety of different factors which are influential, there is the demand for exporting products, the level of demand on the domestic market, and the overall situation in the economy of the country. Insofar as different factors affect the level of trade, including the GDP rate, inflation, employment rate and others, which are not examined in this paper, it is impossible to deduce the determinant correlation between these two factors. However, in the literature it is proved that there is an existing relationship between the exchange rate volatility and trade, e.g. by the above mentioned scientists such as McKenzie and Brooks and Asseery and Peel [10]. In effect, the higher the exchange rate of the domestic currency, the lower the level of net export, because the parity of consumer's power becomes lower. Furthermore, the more stabilized the exchange rate of domestic currency is, the more stabilized the trend of export or import in the country is, depending on the focus of the country.

In Ukraine it is significant to mention the National Bank and its artificially restrained exchange rate of currency, which dramatically distort the real value of net export and the situation on the economic market in general. The National Bank of Ukraine artificially restrains the exchange rate of currency because it is not profitable when export dominates over import. This causes an increase in the exchange rate of Hryvna, which in turn might cause the default and lead to a collapse of the economy. In such a manner it is obvious that exchange rates have a significant impact on foreign trade in different countries, affecting the price ratios of exports and imports, causing a change in the domestic economic situation, as well as affecting the competitiveness of firms and profits of enter-

prises. Using the exchange rate, entrepreneurs compare their own cost of production to global market prices. This makes it possible to reveal the results of foreign trade operations of individual companies and the country as a whole. Sharp fluctuations in the exchange rate increase international economic instability, including monetary and financial relations, cause negative social and economic consequences, and the loss of some gains in other countries.

The situation which Ukraine has to face is the devaluation of the national currency, which makes it possible for exporters in this country to lower prices for their products in foreign currency, receive an award at the appreciated exchange proceeds of foreign currency to the cheapened national one, and sell products at prices lower than the world average prices. All this leads to their enrichment with at the expense of the material losses of the domestic country. But at the same time the depreciation of the national currency increases the cost of imports, as for the same amount in their currency foreign exporters are forced to raise prices, which stimulates their growth in the country, reduction of imported goods and the use or development of the national production of goods instead of imported ones.

In the case of Ukraine, the decline in the exchange rate reduces the real debt in the national currency and increases the severity of the external debt denominated in foreign currency. It becomes unprofitable to export the profits, interest, dividends received by foreign investors in the currency of the host countries. These profits are reinvested or used in order to purchase goods at domestic prices and their subsequent export.

Thus, it is possible to summarize that the current situation in Ukraine is extremely difficult, and external financial support could alleviate the crisis. Of course, entirely due to international financial resources there would be no possibility to solve the deep economic problems of the country. It would be very risky if Ukraine decides to live only at the expense of foreign support. It is very important as well as the attractiveness of Ukraine for the private capital. It is essential to have a look for representatives of international businesses that would like to invest in the development of the Ukrainian economy, insofar as the investors would inculcate the new equipment, technology, workplaces, and raise new export opportunities of the country.

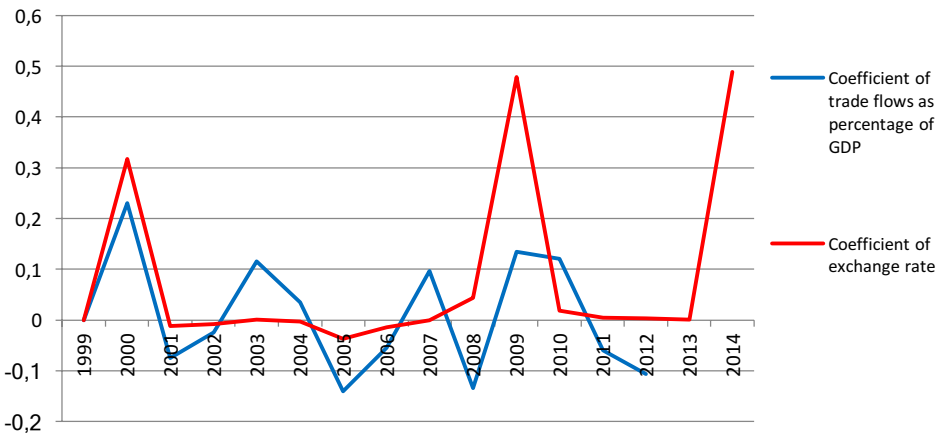

Figure 1. Fluctuation of Exchange Rate and Growth Rate of sum of exports and imports divided by values of GDP.

Note: In the graph the fluctuations of the coefficient of the exchange rate (of the amount of Hryvnas to 1USD) which go downward mean a positive tendency, and the upward movement means a negative trend

4. Conclusion

The authors of this paper have considered the question of the exchange rate volatility and its effect on trade. The analysis showed the theoretical base by the traditional school, the risk portfolio school and some alternatives. The followers of each of the abovementioned schools had various assumptions and theories; however, there is still no determinant convention concerning the value and direction of the influence of the exchange rate. This is caused by a variety of factors which can influence the trade; these factors include the level of gross domestic product, rate of inflation, the unemployment rate and others, not less significant factors. The authors have also analyzed the measuring volatility of the exchange rate and examined the fact that there are concerns by the economic agents about the usage of just the nominal exchange rate in the short-run time period. It means that economical agents who are interested in cooperation in the long-run period of time need a real exchange rate. It stems from the fact that the nominal growth rate includes the inflation. And the real exchange rate reflects the growth in real product. It has been examined on the example of the Ukrainian exchange rate volatility and its influence on the trade. The time span used in the work includes the years from 1999 to 2014, with the help of which the authors have demonstrated the fluctuation and correlation between these two factors. From the graph it has been possible to make the conclusion that even if there was no significant visible correlation between trade and the exchange rate volatility, it does not mean that there is no relationship between these two factors, because there are a lot of factors which affect the level of trade.

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Potential fiscal and non-fiscal consequences of introducing a poll tax in Poland

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ABSTRACT

The inspiration to take up the issue of the poll tax resulted from the desire to verify the claims made by the supporters of the introduction of this tax in Poland in relation to its amount. For this purpose, the simulation of the quota rate of this tax, assuming compensation of the total income from the income tax on natural persons, has been carried out. In addition, potential effects of the introduction of this tax in the fiscal and social areas have been subjected to analysis.
The analysis of the simulation of replacing the Personal Income Tax with a poll tax brings the conclusion that the poll tax would not gain acceptance in Poland nowadays. Potential consequences of this change must be considered not only in the fiscal, but above all – social context. The rates of the poll tax assessed on the basis of the concept of its followers are regressive. This is a disqualifying factor of this tribute, because it would bring a number of undesirable consequences to the economy and society.

Keywords: vpoll tax, capitation tax, head tax, Personal Income Tax .

1. Introduction

Proposals of reforms or even modifications to the tax system are common elements of election programs. Such debates, as well as the subject literature show that the most intense discussion focuses on the model of income taxation, including a demand for the implementation of an expanded base of the flat-rate, dual or linear tax [Bird and Zolt 2005, pp. 937-943; Boadway 2005, pp. 910-927; Zee, 2005; OECD 2006, pp. 71-91; Keen, Kim and Varsano 2008, pp. 712-751; Korolewska 2008]. Sometimes, especially during election debates, the liquidation of the personal income tax and replacing it with the poll tax are postulated. The supporters of such taxation belong primarily to the representatives of the neo-liberal economic mainstream.

The income tax on natural persons in Poland is characterized by subjective and objective universality – annually, this tax is accounted by more than 25 million taxpayers, and its scope excludes only a few types of revenues, which usually are taxed differently (the group of this exemption includes primarily revenues from agricultural activities, subject to agricultural tax). In a broad context, it is used for non-fiscal purposes as well. This tax is also perceived in the context of building a democratic civil state. The personal nature of the income tax on natural persons, creating the opportunity to take into account the taxpayer's ability to pay, and the need for its independent settlement, make it be – regardless of weight – the public tribute that is most visible and consciously borne by the taxpayers. For this reason, a change of it, or even its mere announcement, evoke great interest and strong emotions among taxpayers.

The inspiration to take up the issue of the poll tax resulted from the desire to verify the claims made by the supporters of the introduction of this tax in Poland in relation to its amount. For this purpose, the simulation of the quota rate of this tax, assuming compensation of the total income from the income tax on natural persons was carried out. In addition, potential effects of the introduction of this tax in the fiscal and social areas were subjected to analysis.

2. The concept, origin and structure of the poll tax

A poll tax is a form of a personal tax payable in the form of a fixed, nominal amount from each taxed person, irrespective of their wealth or income received [Burns 1992, p. 10]. The tax payer is a subject and object of taxation, which is characteristic of the oldest and primitive tax systems. A poll tax can be literally understood as a tax paid on the head, a person, that is for

the reason that the person (taxpayer) is alive. This tribute does not allow the use of tax preferences in the form of tax reductions, exemptions and exclusions [Owsiak 2005, p. 160].

For the first time the poll tax was mentioned as early as in the Book of Exodus chapter 30 in connection with the construction of Noah's ark. It was established in order to meet the existing financial demand and was a single tribute charged to all men over the age of 20, regardless of their economic status. The poll tax, introduced in line with the principle that the rich should not give more, and the poor not less than half a shekel, has the characteristics of particularly understood justice and the universality of taxation [Gomułowicz 1995; Hall and Rabushka 1998, p. 34; Gomułowicz 2013, p. 21].

There is evidence verified by historians that in Mesopotamia the poll tax amounted to one cow from each father of the family [Rabushka 1996, p. 18]. The institution of the poll tax was also known in Ancient Greece [Koranyi 1961, p. 76]. In Rome, the poll tax (tributum capitis) was introduced by Emperor Augustus in 27 BC [Nutbrown 2001, p. 97]. The tribute got widespread in the Middle Ages and was an important source of budget revenues until the nineteenth century. Typically, it was applied in case of emergency needs of the country, mainly for military purposes. There are two types of poll taxes: general (common) and quota. The first was personal and was enforced by the tax administration directly from taxpayers. Usually it took into account the taxpayers' ability to pay by classifying them into different classes and the use of different tax rates. The quota poll tax was a burden to a well-defined social group, according to, e.g., territorial, religious, professional criteria. Such a community was required to pay a defined quota, and its representatives distributed the height of the load on each member of the group [Rybarski 1935, p. 262 and 263].

Any implementation of the poll tax was met with social disapproval and repeatedly led to demonstrations, or even revolts. In France, it led to the outbreak of the Revolution in 1789. [Morrisson and Snyder 2000, p. 61]. The tax introduced in the nineteenth century in New Zealand and Canada helped reduce the mass influx of immigrants from China [Murphy 1994, p. 34 and 49; Murphy 2003, p. 52; Li 2008, p. 128]. In the United States, it was a discriminatory tool to eliminate African-Americans from the social and political life [Keyssar 2000, p. 86]. The tax introduced in 1989 in Scotland and in 1990 in England and Wales was diplomatically called the community charge, and the price of its implementation was Margaret Thatcher's loss of the chair of the Prime Minister [Burns 1992, pp. 10-15]. Today the poll tax is levied only by radical Muslims on non-Muslims and is called Jizya [Emon 2012, p. 97].

3. Simulation of the height of the poll tax in Poland

What is important for the taxpayers, is the total burden borne because of taxes, while for the public authority – the amount of total receipts and their distribution among administrative levels are the things that matter. The receipts from the tax on personal income, unlike the receipts from any other taxes in Poland, are divided between three groups of public funds as well as between non-profit organizations. The fiscal importance of the income tax from individuals is expressed not only, or even not primarily, by the amount of state budget revenues from its title. The share of local government units in this tax must be considered, as well as the health insurance premiums deductible from it. The total amount of the receipts from the tax in question is supplemented by lump-sum forms of taxation that supply the state budget (lump sum on recorded income and flat-rate income tax revenues of the clergy) and municipal budgets (tax card).

Total revenues from the income tax on individuals presented in Table 1 prove that it is the most efficient tool for collecting public funds. These revenues are also the amounts needed to cover the funds lost in case of a change in personal income taxation or even elimination of the income tax on individuals. On the basis of these data, an attempt was made to estimate a hypothetical rate of an annual and monthly poll tax. The nominator in the calculation is the total revenue from the income tax on individuals, while the denominator specifies the number of taxpayers who should be required to pay the poll tax.

Estimating the rates of the poll tax was based on the draft of the law on the poll tax by I. Kasza [2004], under which the signatures were collected by the Union of Real Politics within the civic legislative initiative (see: Equation 1). This concept assumed the exemption of minors and students under 24 years of age[1] . For obvious reasons, prisoners[2] and emigrants[3] would be excluded. Monthly commitment would amo-

[1] The number of people belonging to the learning group under 24 years in Poland as of 31.12.2014 was 9 200 102 [GUS 2015].

[2] The number of prisoners in Poland as of 31.01.2014 was 80 129 [Służba Więzienna 2015].

[3] The number of Polish emigrants in 2015 was 2 397 000 [GUS 2016].

unt to PLN 210. This project is still praised by the then leaders of the party. They praise the simplicity and the small volume of the contents of the Act, contained on three sides of an A4 paper sheet. What is also worth mentioning is the provision of the Act, which highlights the daily rate of this tax. The daily rate would be PLN 7 and would be paid even by persons staying temporarily in Poland, including tourists. The use of the daily rate would be a fair solution

Table 1: Total revenues from Personal Income Tax in 2010-2015 (in billion PLN)

Revenue type	2010	2011	2012	2013	2014	2015
State budget revenues from Personal Income Tax	28.472	30,.644	31.891	33.395	35.957	37.463
State budget revenues due to flat Personal Income Tax	7.121	7.431	7.918	7.895	7.065	7.577
Shares of municipalities in Personal Income Tax	10.080	11.340	12.077	12.824	13.983	15.289
Taxation of business activities of individuals paid in the form of tax card	0.089	0.087	0.084	0.082	0.079	0.073
Shares of counties in Personal Income Tax	2.797	3.131	3.322	3.513	3.820	4.166
Shares of cities with district rights in Personal Income Tax – county part	10.282	10.969	11.300	11.830	12.698	13.698
Shares of cities with district rights in Personal Income Tax – district part	2.853	3.029	3.109	3.240	3.467	3.717
Shares of provinces in Personal Income Tax	0.882	0.962	1.004	1.054	1.137	1.230
Revenues from premiums on general health insurance in the amount of 7.75%	47.493	50.149	51.935	53.461	55.446	57.777
TOTAL	110.069	117.742	122.64	127.294	133.652	140.990

Source: own elaboration based on: [The Council of Ministers 2011-2016a; 2011-2016b The Council of Ministers, the National Health Fund 2011-2016].

from the point of view of Polish taxpayers and in accordance with the principle of equality by A. Wagner, under which a tax burden should be spread evenly among all taxpayers [Dolata 2013, p. 32 and 33].

Equation 1 shows that the amount of the poll tax in the annual settlement would amount to 5 268.68 PLN. In terms of one month, the tax amounts to 439.06 PLN, which is about 229.06 PLN more than proposed in the aforementioned act. This obligation would considerably exceed the amount proposed by the supporters of the unrealized idea by I. Kasza, and the rate of 210 PLN would not allow to offset the current income lost as a result of hypothetical changes. When it comes to the daily rate of the poll tax, this would be 14,43 PLN. Assuming that the tax burden on the implementation of the poll tax would rest solely on the current taxpayers of the income tax on individuals[4] , the annual rate of this levy would amount to 5 227.75 PLN, and thus it would be comparable to that calculated according to equation 1.

4. Potential consequences of the introduction of the poll tax in Poland

According to the supporters of the poll tax, the Polish tax system should be based on this tax, because it is the most fair of all public levies. They argue that its implementation would contribute to the simplification of the tax system and the planning of subsequent changes in the Polish tax law. However, the proposed reform faces many formal and legal, financial, political and social barriers.

One of the arguments against the implementation of the poll tax is the method of calculating the tax rate. The supporters do not take

[4] The number of taxpayers of personal income in 2015 amounted to nearly 27 million people [Ministerstwo Finansów 2016].

$$\frac{\text{Total revenues from Personal Income Tax in 2015}}{\text{Total population} - \text{number of emigrants} - \text{students under 24 y. o.} - \text{number of prisoners}} =$$

$$= \frac{140\ 990\ 000\ 000\ \text{PLN}}{38\ 437\ 239 - 2\ 397\ 000 - 9\ 200\ 102 - 80\ 129\ \text{people}} = 5\ 268{,}68\ \text{PLN}$$

Equation 1. The annual rate of the poll tax compensating the total tax revenues from personal income.
Source : Own elaboration based on Table 1.

into account the health premium in the great part deducted from the income tax, simplified forms of taxation and participation of the local government in the revenues from the income tax. It can be expected that the calculation of the rate of the poll tax in order to compensate for only the current state budget revenue from income tax from individuals, most probably results from intentional underreporting, finally to demonstrate the reduction of this tax rate compared to the current income tax. This type of calculation is promoted most likely due to the desire to improve its attractiveness. The supporters of the poll tax want to draw attention and convince the average taxpayer, that there is a fairer and less painful way of taxing their income. Conservative and radically liberal political parties wish to acquire a new electorate, which would be tempted by the promises presented during election campaigns. It is also possible that the fact that this method of calculation might result from the ignorance of the supporters of the poll tax on the public finance system. The introduction of the poll tax instead of the Personal Income Tax as the compensation only of the revenue of the state budget would lead to the elimination of the source of funds for health insurance and would deprive local authorities of a very significant source of income. The reform of the personal income tax should be preceded by a clear definition of objectives and a reliable analysis of socio-economic effects, which the proponents of the poll tax have never done.

A major barrier to the implementation of the poll tax stems from the lack of regulation and a plan of long-term policy aimed at its introduction. In addition, any changes in the tax system must have a common acceptance of taxpayers to be effective. Taxpayers are more willing to accept the known forms of taxation, and any attempts to introduce a new personal tax encounter firm resistance in the society. The phenomenon of resistance to any kind of tax reforms has been justified by the fears of the public against an increase in the tax burden. The source of the lack of social acceptance also comes from a frequently negative experience of the previous tax changes. They featured a fragmentary nature and ad hoc activities rather than presented the explicit aims. This reluctance to the changes in the tax system also results from the habits and, consequently, as noted by J.M. Buchanan [1997, p. 88] "the older the tax , the greater is the institutional routine and the more likely is its continuation".

The supporters of the poll tax describe it as a universal, equal and simple tribute of money to the state, which is due from every citizen. In fact, in the past the poll tax was complicated, and was neither universal nor equal for all taxpayers. In addition, the poll tax applicable formerly in Poland and many other countries was by no means a permanent tax. It was passed several times, usually in urgent budget needs. Its simplicity was debatable, since there were a few rates of the poll tax, which depended on social belonging, and the differences in the amount of the lowest and highest rates were enormous[5]. Therefore, it was a progressive tax. The poll tax was not the only tax levied on the population. In the past, apart from the poll tax, other taxes were also used. Moreover, the poll tax was not always applied to all residents. Some citizens had privileges and were exempt from paying it.

Specializing in the study of the phenomena of social and income inequalities, T. Pikkety [2015, pp. 614-617] indicates that a significant issue for a modern welfare state is that the fiscal system, which constitutes its foundation, should maintain the minimum of progressivity, and in any case, it cannot be clearly regressive at the top and cannot adversely affect the poorest. In contrast, the poll tax proposed by his followers would be an extremely simplified re-

[5] In 1520, the poll tax payers in Poland were divided into up to 192 tax categories and the tax rates ranged between 0.5 gr and 300 zlotys.

gressive tax. This means that with an increase in income, the tax rate decreases. Every citizen, regardless of their earned income, would pay the same to the budget. The requested personal tax would not take into account the taxpayers' ability to pay. The citizens with low income or those not having it at all, would not afford such high monthly rates. The taxpayers who earn the least, who currently pay about 100 PLN of the Personal Income Tax per month, after the change would have to pay almost 440 PLN of the poll tax per head. This would mean more than a fourfold increase in the tax liability, drastically increasing the percentage of the tax loss in their income. With the introduction of the poll tax, the income tax threshold would be abolished, so the effects of changes would mainly affect the taxpayers living on the brink of poverty, deepening the division of the society into the rich and the poor. The poor would need to borrow in order to settle the liability to the state. They would become slaves of banks, lose all their assets or become homeless. The solution to this problem could be the use of a social variant of the poll tax, assuming the exemption of the people who live below the living wage, but the burden of the tax would be passed on other taxpayers. Moreover, it would force the growth of tax administration to verify the ability to pay the tax, which would be even more difficult if records of the income were not kept.

The proposed reform would certainly raise ethical and social opposition, as a person whose income is up to 2 thousand PLN, would have to pay the same amount of tax as those earning more than 20 thousand PLN per month. This is contrary to the principle of fair taxation. K. G. Holtgrewe, one of the founders of the psychological tax school, suggests that apart from the amount of the tax liability, the sense of tax justice is significantly important [Tax morality 2010]. Also, T. Tyszka in his work entitled „Psychology of economy „ indicates that the starting point in the discussion of the tax justice is a subjective criterion of the phenomenon, that is what, in the opinion of the people, tax construction is just and equitable, and the design of the poll tax will not allow to treat such tribute as meeting these criteria [Tyszka 2004, pp. 502-506].

The introduction of the poll tax would lead to an excessive fiscal burden from the state, which could be a potential threat to the general consent to taxes. Historical experience shows that the poll tax was the cause of many revolts and uprisings. A similar situation can be expected on the streets of Polish cities. Citizens would show their disapproval and dissatisfaction with the introduction of, in their opinion, an unfair tax in lump sum. The use of any deductions or exemptions would be difficult since the omitted group of the taxpayers would feel wronged and firmly oppose the tax preferences. Since the poll tax does not take into account the taxpayer's ability to pay, and its construction does not provide any exemptions from its pay, ethical and social barriers appear. Feelings and emotions directing the taxpayers living in poverty or affected by random situations (a loss of income sources, sudden illnesses, massive layoffs) would lead to protests and rebellions against the affluent people who would pay a small tax, and against the government. That happened in England after the introduction of the poll tax in 1990 by the government of Margaret Thatcher. The poll tax could function only in a country with a totalitarian regime, where the protection of the rich against the social class that does not have income would be provided by the army and the police. S. Owsiak believes that the poll tax is a solution which is "by all means imperfect" and typical of primitive tax systems [Owsiak 2005, p. 154]. It is applied nowhere in the world, which means that it is not a tax favored by any political system. It is not even promoted in the most liberal and neo-liberal tax concepts. The poll tax is mistakenly considered to be the simplest and most equitable tax. In the long term, it would endanger democracy and the stability of the society, leading to a rebellion and an authoritarian system.

The supporters of the poll tax believe that this form of taxation would solve a long dispute over how to tax the income of farmers. It can be assumed that the poll tax would be too high a burden for the owners of farms, especially if they were affected by natural disasters (e.g. floods, droughts), demanding production and social support. The change in the taxation of farmers would also reduce the size of agricultural production, making it unprofitable. There would be a drop in the disposable income of farmers, an increase in unemployment in this sector, and in the longer term – the need for retraining.

The supporters of the poll tax believe that the cost of collecting the tax would be significantly lower than the collection of the Personal Income Tax. In their minds, about 15% of the current tax administration could manage the poll tax. Lay-offs among the currently employed Tax Office officials would lead to a reduction in administrative expenditures. In Poland, the tax administration in 2014 employed about 63 thousand officials [Treasury went on a diet 2015]. The costs of tax collection, in particular income taxes, is an irretrievably lost part of the socio-economic development. We are not tal-

king here only about the cost of maintaining the tax administration, but also the costs borne by the taxpayers themselves. Indeed, the poll tax is characterized by simplicity, clarity and precision, but with such a high rate and highly probable resistance of taxpayers, the costs referred to may rise dramatically. Those derogating from paying the poll tax would have to be prosecuted, forced to pay the due tax, and as a last resort, punished with imprisonment. This phenomenon would encourage the authorities to introduce even greater rigor on the part of the tax administration and to increase the tax burden, whereas the society could insist on the introduction of exemptions as a kind of compensation. A major difficulty in enforcing the poll tax would result from abolishing the obligation to register with effect from 1 January 2018 [The Act of 23 July 2015, art. 1]. This would enhance the phenomenon of tax evasion. Undoubtedly, there would be an increase in the number of citizens who have not updated their place of residence neither in the Social Security base nor another register. Fraudsters would report false addresses, and tax authorities would not be able to verify the taxpayers, nor make them pay their liabilities.

The supporters of the poll tax argue that an important advantage would be to abolish the surveillance of the citizens' incomes. Taxpayers would not have to document their income and assets. The state would not be interested in whether the Polish people have some income and where it came from. The taxpayer could work nowhere, as long as the poll tax was paid. It would only be in case of evasion of payment of obligations that the process of debt recovery was initiated. This tax would have to be paid by the persons currently operating in the informal economy. Considering the effects of redistributive taxation, we must also take into account the burden arising from social insurance contributions, which is completely overlooked by the supporters of the poll tax. Therefore, taxpayers would still have to reveal the source and amount of their income for social security purposes.

On the one hand, the poll tax would be a strong incentive for foreign investors and entrepreneurs to transfer production and services to Poland. They would pay lower taxes, so Poland could be considered as a tax haven. Foreign companies operating in the Republic of Poland (RP) would provide the budgetary revenues from other taxes. The result of these activities could be an increase in the trade deficit caused by growing demand for consumer goods and investments. On the other hand, this could be seen as a manifestation of harmful tax competition. The amount of the poll tax would be particularly mild for foreigners and foreign entities which would use Poland to transfer their profits and avoid paying higher taxes in their home countries.

The draft of the law on the poll tax contains provisions relating to the application of a daily rate of this levy. The author of this project suggests that it has its logical and fiscal reasons, as tourists, delegates or foreign carriers residing in Poland are the same beneficiaries of goods and services provided by the public authorities, as the citizens permanently residing on the territory of Poland. Such a solution, however, faces a number of serious problems both of an economic and legal character. The collection of a daily poll tax is a problematic issue. The solution could involve registering foreigners entering the Polish territory and collecting the tax at the border upon their leaving the country. Customs officers or border guards could be made responsible for that. However, this is tantamount to an increase in the cost of collecting this tax. Furthermore, the implementation of the daily rate of the poll tax would be difficult because of the current Schengen Agreement, which Poland is a member of. It says that the movement of people of all nationalities should be free within the zone. The reintroduction of border controls, and collection of the daily tax could result in suspension of membership or even exclusion of Poland from the Schengen area.

Elimination of the Personal Income Tax and replacing it with a seemingly uncomplicated poll tax would free the Polish from the onerous obligation to submit annual tax declarations, which currently denies the principle of the expediency of taxes. The rate of the poll tax would be defined by the law. Taxpayers would not have to worry about a wrong calculation of the tax and its potential consequences. They would not have to use the services of accountants and tax advisers, and thus would save time and money. There would be no need for advance payments and waiting for a possible return in the event of tax overpayment. This means that the taxpayers would keep the amount of income decreased by the poll tax, which would allow them to thoughtfully manage their household finances and make long-term financial planning. There would be no loss of revenues, which arises in the advance payment system. Currently, the amount of refunds due to overpaid advances exceeds the due tax. In practice, this would mean a kind of end to crediting the state by the taxpayers without an accompanying calculation of interests.

The poll tax would be likely to prevent refugees from Syria, Libya and Eastern Europe from coming to Poland. Most people entering Europe are economic immigrants who take advantage of the migration crisis. Their main objective is to acquire high social benefits. Following the poll tax introduced in the nineteenth century in New Zealand and Canada, this tax would help reduce the influx of immigrants, especially the illegal ones.

5. Results

The analysis of the simulation of replacing the Personal Income Tax with the poll tax brings the conclusion that the poll tax would not gain acceptance in Poland nowadays. Potential consequences of this change must be considered not only in the fiscal, but above all – social context. The rates of the poll tax assessed on the basis of the concept of its followers are regressive. This is a disqualifying factor of this tribute, because it would bring a number of undesirable consequences to the economy and society. Strong regression of the tax burden for those with high income would affect negatively the dynamics of wealth inequalities, actually deepening the current problem of excessive disparities in the distribution of income and wealth, confirmed, among others, by the NBP's report on the state of the wealth of the Polish people [NBP 2015]. Stratification of income would be a potential threat to the general acceptance of taxes. Regressive taxation of income would make mainly the poor and middle income tax payers provide for the state.

Based on the theoretical and historical data, it can be concluded that the construction of the poll tax does not bring it closer to the idea of a fair tax. The construction of the poll tax boils down justice and, consequently, the equality of taxation to the same principles to all taxpayers, without considering the individual capacity to bear the tax burden. It is not fair when a person with low income pays the same amount of tax as a wealthy person, for whom the burden of equal amount of tribute is a tiny restriction on property rights. Therefore, the fairness and equality of taxation would be apparent. It can even be said that this tax would be a denial of tax justice. The implementation of the poll tax in Poland would violate Article 2 of the Polish Constitution, according to which the laws, including taxation, should be the manifestation of the principles of social justice.

The project of introducing the poll tax can be rejected. It corresponds only to a utopian political system, based on solidarity, equality and social and material prosperity. Attractive in its apparent simplicity, the poll tax would lead to criticism from taxpayers and would jeopardize the stability of the country.

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Capital outflow in the countries exporting oil and gas as a deterrent to the economic development

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ABSTRACT

The economies of the countries exporting oil and gas generally have a positive balance of trade and a current account surplus. However, among them there are countries facing the problem of capital outflows under the financial account of the trade balance, which reduces financial resources for the economic growth and diversification.

The main reasons for capital outflows lie in the specific features of the national law concerning foreign exchange as well as in the psychology of the behaviour of the economic agents carrying out activities on the territory in question. The capital outflow is caused not only by a higher exposure of business operations, corruption, weak competitiveness of the economy etc. The authors have demonstrated that the most vulnerable countries exposed to the highest level of the capital outflow risk are the countries with hybrid exchange rate regimes, in contrast to the countries adopting hard exchange rate pegs or the floating exchange rate regime. The changes in the behaviour of economic agents influencing the capital outflow during the transition of their currency exchange rate regimes to the floating regime have been studied on the example of Russia. Among the main parameters indicating excess capital outflows, the percentage of foreign currency denominated assets and liabilities in bank balance sheets has been chosen.

In the long term the pattern of behaviour of the economic agents in Russia will be similar to that of those in Norway and Canada, where even severe fluctuations of local currency exchange rates do not make money aggregates, the level of economy's monetization and the percentage of foreign currency denominated assets and liabilities in bank balance sheets fluctuate significantly.

Keywords: oil, gas, capital outflow, price shock, exchange rate regime.

1. Introduction

Capital outflow is one of the central problems that developing countries face. The lack of financial resources leads to the slowdown in renovation of fixed assets, contraction in lending and decline in the economic growth. The capital outflow under financial account may have no impact on the general level of the economy's monetization, since the "broad money" aggregate that includes cash in circulation as well as current and deposit accounts of bank customers, is usually chosen out of all money aggregates characterizing it.

As a rule, economists compare the monetization indicators among countries guided by comparable broad money indicators. However, there are customers' foreign currency accounts in the structure of this aggregate and they should be considered separately, especially in the economies where the percentage of foreign currency denominated assets and liabilities in bank balance sheets is excessively high.

The process of converting the assets and liabilities of bank balance sheets into foreign currency is related directly to the capital outflow. In our study, we are going to analyze the monetization fluctuations using different monetary supply aggregates in order to define more accurately its characteristics and patterns in the countries exporting oil and gas that have similar regulation practices.

2. Literature overview

The economic modeling for regulating the level of the economy's monetization employs two models: DSGE and ABM.

Dynamic Stochastic General Equilibrium (DSGE) models

The theoretical basis for this type of modeling are macroeconomic grounds in the framework of which the general dynamics of the economic system is the result of economic agents' optimization activities. At a micro-level the DSGE models consider economic agents' preferences and limitations that determine the range of their activities. This makes the DSGE models qualitatively different from the macroeconomic models in which aggregate indices are the framework for analysis. The parameters of preferences and limitations are structural, and therefore not influenced by the changes in the economic policy.

The active use of the DSGE models began at the end of the 1990s; they owe their wide expansion to being used by the Central Banks of different countries for elaborating the economic policy. Such models as SIGMA [Erceg, Guerrier, Gust 2006. pp. 111–144] of the Federal Reserve System (the USA), NAWM [Christoffel, Coenen, Warne 2008. p. 58] (European Central Bank), ToTEM [Murchison, Rennison 2006, p. 79] (the Bank of Canada) as well as GEM [Pesenti 2008. pp. 243–284] and GIMF [Kumhof, Laxton, Muir, Mursula 2010, p. 13] used by the IMF for studying the international economy are good examples.

In terms of its structure, any DSGE model is comprised of three essential components [Fagiolo G., Roventini A. 2012, pp. 27-29]:

- the dynamic version of the IS equation for modeling the national income;
- the New Keynesian Phillips Curve for modeling inflation;
- the Taylor rule for modeling the interest rate.

In addition to the mentioned key components, DSGE modeling requires distinguishing the trend and cyclical components, calculating a short-term deviation from the equilibrium, calculating the deflated variables, etc.

In contrast to the DSGE models as models of balanced dynamics, the Agent-Based models (AB) are new to the economic science; they study the economy as a complex misbalanced evolutionary system of economic agents.

Agent-Based models (ABM)

The "perfect storm" that followed the collapse of Lehman Brothers investment bank on 15 September 2008 and set off the Great Recession questioned the efficiency of the DSGE models as a leading tool for evaluating and elaborating the macroeconomic policy in the period of global crises. As one of the leading American economists P. Krugman noted, not only had the orthodox economists not managed to predict the approaching crisis, but they also had not even considered such a possibility and, what was even worse, they had been unable to provide the politicians with an efficient means for propelling the international economy into the phase of sustainable growth [Krugman 2011, pp. 307-312]. The assumptions of absolute rationality in neoclassic models proved the DSGE models incompetent in terms of evaluating and forecasting crisis-like phenomena arising by reason of the nonlinear character of the economic agents' behaviour.

The main goal of agent-based modeling is building the models proceeding on the basis of realistic assumptions of the behaviour and interaction of the agents. At the same time, the complex heterogeneous nonlinear character of the interaction between the agents imposes renouncing any kind of theoretical simplifications (like the agents' representativeness assumption or the idea of the economic system equilibrium), typical for the DSGE models, and concentrates fully on the misbalanced dynamics maintained by the interactions of heterogeneous agents. Therefore, in contrast to the neoclassic models, the main principles of the agent-based models are bounded rationality, heterogeneity of the agents and misbalanced dynamics of their interactions.

The main characteristics of the Agent-Based models are as follows [Fagiolo, Roventini 2012, p. 16]:

"The bottom-up view". The aggregate characteristics of the economy "populated" by economic agents are received as the macro-result of the dynamics of these agents. On the contrary, in the neoclassic models the analysis is carried out on the "from top to bottom" basis and it provides a definition of a representative agent bound with tough theoretical limitations of the system's rationality and equilibrium.

Heterogeneity. The agents are always inhomogeneous in terms of all their characteristics. Their aggregate features are the consequence of the repeated local interactions and cannot be defined by the requirements of limitations and equilibrium.

Nonlinearity. The character of the agents' interactions in the model is nonlinear. The correlation between the modeling level and macro-level is also nonlinear.

Endogeneity of interactions between agents. The decisions that an agent is taking at the present moment through the adaptive expectation mechanism depend on the decisions of other agents at preceding moments.

Bounded rationality and learning abili-

ty. The agents in the model are in free search within the changing dynamic environment which contributes to the emergence of innovations and subsequent emergence of new types of the behaviour of agents allowing quicker adaptation to the changing environment.

Genuine dynamics. The model is formed by irreversible dynamics. This implies that the agents form their own expectations of the future on the basis of information about preceding system conditions.

Constant endogenous innovations. The economic systems are unsteady. Their continuous development is related to the emergence of something new that incites the agents to learn and adapt.

The market selection mechanisms. The agents go through market selection criteria that can be complex and multidimensional.

The general structure of agent-based models

There is a system of agents (consumers, companies etc.) that can be organized according to the principle of hierarchy, the size of which can change with time. At any specific time t each agent i is characterized by a finite number of microeconomic variables $X_{i,t}$ and the macroeconomic parameters vector θ_i fixed within the time period considered. The economy is generally characterized by a certain number of fixed macroeconomic parameters θ_i.

At any specific time $t>0$ under given initial conditions and selected micro- and macroeconomic parameters $X_{i,0}$, one or more agents are chosen and their microeconomic variables are updated.

The agents selected for the update stage collect the available information on the preceding and current condition of subsets of other agents with whom they usually interact. On the basis of collected data the agents form the rules in the way that makes them similar to empirical data that an investigator might have received at the preliminary stage.

After the update stage is finished, a new set of macroeconomic variables flows into the economy for the next interaction. The aggregated values of X,t are calculated as the sum or average value of particular characteristics, similar to the definitions of statistical aggregates like the GDP, unemployment, etc.

Due to the nonlinear character of the decisions taken by the agents, the dynamics of micro- and macro variables can be described by random processes, therefore an investigator is forced to recourse to computer simulation in order to analyze the behaviour of the model in question.

The agent-based models can be a powerful tool for elaborating and taking decisions in the area of the economic policy. In view of the complex nonlinear character of economic decisions, these models have a range of advantages over the neoclassic ones which can be divided into two categories: theoretical and empirical.

Unlike the neoclassic ones, agent-based models do not imply theoretical limitations like the equilibrium assumption and rational expectations or representative agent assumptions, for example. The absence of strict theoretical requirements affords substantial flexibility of the model-building process causing no damage to its analysis. This approach implies that an investigator can replace the assumption if the model does not meet the expectations. In case of the neoclassic model it is impossible to simply replace one optimization assumption with another if the model has proved to be unsustainable, as this can have significant impact on its analytical solution.

As compared to the neoclassic models, the structure of the agent-based models allows applying them more easily considering the available information. First, it is possible to check the data comprising the model for compliance with the real facts; otherwise stated, to select the assumptions of the agents' interactions and individual behaviour in a way that will make them accord with the observations. Second, it is possible to check the modeling outcome for compliance with the real facts in a way that will make the model reproduce only the stylized facts that are of interest.

In order to conserve the analytical solubility, the neoclassic models are, as a rule, constructed for explaining one or two stylized facts. On the contrary, an agent-based model can easily explain a number of various empirical observations.

Nowadays this type of models is used to elaborate policies in different areas like the economic growth, industrial dynamics, market design, environment regulations and traffic control. However, in the economic literature considering agent-based models the main focus is on their use for evaluation of the influence of the macroeconomic policy during and after crises.

In particular, the agent-based models can be classified according to three main areas of the macroeconomic policy: fiscal policy, monetary policy and banking regulations.

3. Methodology

In the international practice there are three types of exchange rate regimes for the countries with a large share of the hydrocarbons

export in the GDP: the exchange rate fixed against the U.S. dollar with minor deflections in the longer term; the hybrid exchange rate regime, in which the central bank can sometimes intervene into foreign exchange trading, thus guiding the national currency exchange rate to the desired level or range; the floating exchange rate that implies limited intervention of the central bank into foreign exchange trading and that such intervention is counterproductive.

In the countries with hard exchange rate pegs the fiscal policy should be well-balanced and the inflation level should be low. Besides, the time intervals between the exchange rate pegs can last for decades which ensures the highest degree of trust to monetary regulatory authorities.

The hybrid exchange rate regimes (soft exchange rate pegs), characterized by maintaining a constant value of the currency against another currency or a currency basket, are typical for countries with higher inflation and an unstable budget system. These regimes are vulnerable to financial crises, and therefore the authorities of such countries are forced to devaluate the currency on a regular basis and reconsider the interim exchange rate pegs and parameters of the currency bands.

The floating exchange rate regimes allow absorbing the impact of the international goods market price shocks on the national fiscal system. However, in case of a weak economic structure this regime is fraught with inflation shocks along with significant dependence of the national economy on the external capital flows. This regime is adopted in most developed countries.

The transition of the Russian economy from the managed "dual currency basket" exchange rate to the floating exchange rate regime in 2014 allowed assuming that this parameter has similar influence on the countries with the same regime of national currency exchange rate management. Among the countries with no hard exchange rate pegs Canada, Norway and Mexico were chosen [Ershov 2015. pp. 32-50].

The authors' task was to search for similar mechanisms and, consequently, the parameters of economic management in general in the light of a significant influence of the share of the hydrocarbons export in the total GDP of the countries.

4. Data

Among the essential parameters characterizing the macroeconomic situation in the countries considered the following were adopted:

- the Gross Domestic Product;
- the national currency exchange rate against the U.S. dollar;
- inflation level for the expired year;
- money aggregates M2 and M2x;
- international reserves;
- bank deposits;
- commercial bank loans.

Besides, such parameters reflecting the condition of the hydrocarbons markets of the countries considered as: the volumes of oil export, consolidated budget receipts, trade balance, the share of total oil export revenue in the GDP of the country considered and the current account of the balance of payments, were also admitted for consideration. As basic universal variables the U.S. dollar index and dynamics of Brent oil price per barrel were adopted.

At the first stage the study was carried out on the basis of the statistical data obtained from official sources of the countries considered and denominated in the national currency. With the purpose of consolidating all the parameters into the unified system of measurement, the study was carried out on the basis of the time series reflecting the rates of change of chain-weighted monthly increments of the parameters considered.

Table 1: Consolidated table of correlation between GDP values in national currency and financial market indices (from 2000 to 2015 year)

Countries	Nominal GDP, national currency billions	USD/ national currency	EUR/ national currency	Inflation,% per year	M2, national currency, billions	Int. reserves, USD billions	Deposits, national currency thousands	Credits, national currency,thousands
Russia	1,00	-0,14	-0,16	0,07	-0,03	-0,13	-0,09	-0,12
Norway	1,00	-0,02	0,01	-0,10	-0,26	0,03	-0,22	-0,08
Canada	1,00	-0,41	-0,06	0,33	-0,13	0,31	0,26	-0,04
Mexico	1,00	0,16	0,21	0,02	0,30	-0,15	0,00	0,52

Source: Authors' calculations based on the results of investigations.

Table 2: Consolidated table of correlation between GDP values in national currency and oil products export indices (from 2000 to 2015 year)

Countries	Oil export, USD million	Consolidated budget revenue per month, national currency billions	Trade balance USD billions	Oil export/ GDP	Current account of balance of payments, USD billion	USD index	Brent oil	Gold
Russia	0,96	0,05	0,19	0,91	-0,16	0,35	-0,28	-0,51
Norway	-0,06	0,04	-0,09	-0,97	0,00	-0,12	0,10	-0,13
Canada	0,44	-0,12	-0,08	0,44	-0,44	0,81	-0,87	-0,39
Mexico	-0,37	0,03	0,20	-0,36	0,10	0,86	-0,95	-0,70

Source: Authors' calculations based on the results of investigations.

No correlation was found between the dynamics of the chain-weighted GDP increments (in national currency) and essential macroeconomic parameters (Table 1). However, these figures showed a high level of dependence on the hydrocarbons export indicators in the economies considered (Table 2).

Besides, as shown in Table 2, a high level of dependency of the series considered on all basic parameters introduced earlier was detected.

The detected patterns allowed the investigators to assume the existence of immediate relations of a higher level between the parameters of the financial market reflecting the economic situation of the countries considered and prices for oil, the export of which is the principal source of income.

The results of studying the levels of correlation between the main national currency denominated parameters of the countries exporting hydrocarbons with the floating exchange rate regime and the main indicators of the international market show that in all countries of the group considered there is express unidirectional dependence of growth rates of the national currency exchange rates and the current accounts of balances of payments related to the increase in Brent oil prices growth rates.

In view of the abovementioned, it was decided to abandon the chain-weighted increment model typical for such cases and to apply one currency, the U.S. dollar, as the basic currency for estimating the cost of hydrocarbons in order to convert the values into a unified system of measurement.

The results of the analysis show clearly a high level of correlation of all parameters of the macroeconomic level of the countries considered denominated in one currency with the Brent oil price per barrel. This allows for quite accurate modeling of the economic agents' behaviour within each of the economies considered. The existence of countries with similar economic culture having a long-standing currency regulation cycle guarantees possessing information on the economic agents' behaviour in the Russian economy after the transition period expires.

5. Model

The basis for analyzing the level of the dependence of Russian economic agents on the dynamics of oil prices is the agent-based model built upon the interactions of households (legal and natural entities), commercial banks and the Central Bank. The system of indicators of the legal entities is shown in Table 3,4,5,6.

Table 3: Organizations

Assets		Liabilities	
M_{tf}*	M_{tf}	D_f*	D_f
	M_{tf}^C		
M_{df}*	M_{df}		D_f^C
	M_{df}^C		
B_f*	B_f	D_{of}*	D_{of}
	B_f^C		D_{of}^C
I_n			

Assets:

M_{tf}-demand deposits in national currency
M_{tf}^C- demand deposits in foreign currency
M_{df}* - deposit accounts:
M_{df}- deposit accounts in national currency;
M_{df}^C- deposit accounts in foreign currency;
B_f*- obligations:
B_f- obligation in national currency;
B_f^C - obligation in foreign currency;
I_n- other assets.

Liabilities:

D_f*- credits to organizations
D_f- credits in national currency;
D_f^C- credits in foreign currency
D_{of}*- obligations
D_{of}- obligations in national currency
D_{of}^C- obligations in foreign currency

Table 4: Individuals

Assets		Liabilities	
M_{0h}		D_h	
C_h			
M_{th}*	M_{th}		
	M_{th}^C		
M_{dh}*	M_{dh}		D_h^C
	M_{dh}^C		

где:

Assets:

M_{0h}- cash in circulation;
C_h- consumer expenditure;
M_{th}*- demand deposits;
M_{th}- demand deposits in national currency;
M_{th}^C- demand deposits in foreign currency;
M_{dh}- deposit accounts in national currency;
M_{dh}^C- deposit accounts in foreign currency.

Liabilities:

D_h-liabilities in national currency;
D_h^C- liabilities in foreign currency.

Table 5: Commercial banks

Assets		Liabilities	
K_{cb}		M_{tf}* M_{th}*	M_{tf}
K_b^C			
O_b			M_{tf}^C
B_b			
B_b^C		M_{df}* M_{dh}*	M_{df}
D_f D_h	D_f		M_{df}^C
	D_f^C		

K_{cb}- accounts at the Central bank
K_b^C- accounts at the foreign banks
O_b- mandatory reserves
B_b- obligations in national currency
B_b^C- obligations in foreign currency

Table 6: Central bank

Assets	Liabilities
IR	M_0h
	G
C_{cb}	K_{cb}
C_{cb}^{c}	
B_{cb}	

IR-international reserves
C_{cb}- credits to commercial banks in national currency
C_{cb}^{c}- credits to commercial banks in foreign currency
B_{cb}- stocks in national currency
M_0h- cash in circulation
G- central government requirements
K_{cb}- accounts at the Central bank

In accordance with the results of the previous studies the input parameters were: Brent oil prices, the national currency exchange rate and the parameters reflecting the share of oil and gas revenues in the budget. In view of that, the following indicators describing the financial flows of the economic agents' interactions mentioned above were adopted for analysis.

f1 cash in circulation h;
f2 demand deposits in national currency;
f3 demand deposits in foreign currency;
f4 deposit accounts in national currency;
f5 deposit accounts in foreign currency;
f6 liabilities in national currency;
f7 liabilities in foreign currency;
f8 demand deposits in national currency;
f9 deposit accounts in foreign currency (nominated in national currency);
f10 deposit accounts in national currency (nominated in national currency);
f11 deposit accounts in foreign currency;
f12 credits in national currency;
f13 credits in foreign currency (nominated in national currency;
f14 deposit accounts in foreign currency (nominated in foreign currency);
f15 deposit accounts in foreign currency (nominated in foreign currency;
f16 credits in foreign currency (nominated in foreign currency);
f17 accounts at the Central bank;
f18 accounts at the foreign banks;
f19 mandatory reserves;
f20 obligations in national currency;
f21 obligations in foreign currency;
f22 credits to commercial banks in national currency;
f23 credits to commercial banks in foreign currency;
f24 international reserves;
f25 Investments of Central bank in the securities in national currency;
f26 central government requirements to Central bank.

The statistical data showing the economy's monetization level and its dependence on the export of hydrocarbons were adopted as parameters of the study:

x1 GDP nominal USD /month.;
x2 USD/RUB;
x3 Inflation rate, % ;
x4 Money supply M1, bn.USD;
x5 International reserves, bn. USD;
x6 Deposits in banks, t. USD;
x7 Credits to economy, t. USD;
x8 Oil export, mln. USD;
x9 Revenues of state budget, bn. USD;
x10 Trade balance, bn. USD;
x11 Oil export/GDP nominal;
x13 USDX – dollar index;
x14 Brent, USD.

The results of the primary correlation analysis showed a high level of dependence of the total volume of current foreign currency denominated demand deposits and the total volume of foreign currency denominated time deposits of legal entities on the nominal Gross Domestic Product, national currency exchange rate against the U.S. dollar, money aggregate M1, volume of international foreign-exchange reserves, total deposits on the accounts of Russian commercial banks, the volume of oil products export in USD, the consolidated budget receipts, the U.S. dollar index and Brent oil price.

According to the resulting model, the indicated parameters have a primary impact on the functions describing the financial flows of the legal entities directly related to foreign currency:

1. The current foreign currency denominated demand deposits: F9 (x2,x4,x5,x14)
2. The foreign currency denominated time deposits of legal entities: F15 (x1,x2,x4,x5,x8,x9, x13,x14)
3. The foreign currency denominated bank debts of legal entities: F16 (x10,x11,x14)

Consequently, the initial point of the oil-pri-

ce shock pulse input was detected within the study of the oil prices impact on macroeconomic indicators. According to the model shown in Table 12, the mentioned flows being part of the commercial banks' liabilities, immediately distort the bank balance in case they change. Similarly, , being an immediate constituent of the commercial banks' assets, influences the general performance of the foreign currency component of the bank balance.

The concluding description of the economic agents system was modeled by the authors of the study as follows:

- for the system of households as legal entities:

$$M_{tf}^{c} = \underset{0,0485}{-0,0224} + \underset{1,7419}{1,0462} * X2 + \underset{1,6908}{1,2548} * X4 + \underset{1,9275}{0,9775} * X5 - \underset{0,6337}{0,3823} * X14 + \varepsilon;$$

$$M_{df}^{c} = \underset{0,0129}{0,0175} + \underset{0,0684}{0,1282} * X1 + \underset{0,1553}{0,0671} * X2 - \underset{0,1615}{0,0937} * X4 - \underset{0,2045}{0,1576} * X5 +$$

$$+ \underset{0,2902}{0,4612} * X8 + \underset{0,0151}{0,0149} * X9 - \underset{0,2562}{0,5668} * X13 - \underset{0,0564}{0,0052} * X14 + \varepsilon;$$

$$D_{f}^{c} = \underset{0,0032}{0,0007} + \underset{0,0168}{0,0063} * X10 - \underset{0,0338}{0,0105} * X11 - \underset{0,0055}{0,0038} * X14;$$

- for the system of commercial banks:

$$А_{кб}^{c} = K_{b}^{C} + B_{b}^{C} + 0,0007 + 0,0063 * X10 - 0,0105 * X11 - 0,0038 * X12 + \varepsilon;$$

$$P_{CB}^{c} = -0,0049 + 0,1282 * X1 + 1,1133 * X2 + 1,1611 * X4 + 0,8199 * X5 + 0,4612 * X8 + 0,0149 * X9 - 0,5668 * X13 - 0,3878 + 0,4612 * X8 + 0,0149 * X9 - 0,5668 * X14 + \varepsilon;$$

- for the Central Bank:

$$\Delta А_{цб}^{c} = 0,07 * \Delta D_{df}^{c}$$

ε - small quantity.

In accordance with the studies carried out, a significant influence of the parameters considered on all the agents of the economic system concerned was detected. The upward deviation of the Brent oil price growth rate by 1% causes slowdown in the buildup of current demand deposits by 0.38%, and foreign currency denominated current deposits of legal entities by 0.05%. Such an event might allow the commercial banks to expect a decrease in the growth rates of bank foreign exchange liabilities by 0.56%.

For Russia, which is a country where the share of oil and gas export makes more than a half of its export, the exchange rate regime is of crucial importance [Dvoretskaya 2015. pp. 20-28]. The exchange rate regime affects the evaluation of capital flows and parameters of money supply.

In November 2014 the Bank of Russia changed the exchange rate regime of the Russian ruble, switching from targeting the exchange rate within the currency band of a dual-currency basket to floating. As a consequence, the principles of forming the monetary flows in the financial system of the country changed as well. The Russian national currency became more sensitive to oil prices fluctuations. Despite the increased volatility of the foreign exchange market, the federal budget became more predictable, as the exchange rate fluctuations started synchronizing with the oil prices dynamics and, consequently, the ruble denominated oil and gas budget receipts became more stable than in the times of currency band policy. In effect, the Bank of Russia sacrificed stability of the exchange rate for financial stability.

6. Results

The authors chose countries that have both a floating exchange rate regime and a significant share of oil and gas export in the GDP structure. Apart from Russia, such countries as Norway, Canada and Mexico meet these conditions as well. The dynamics of the share of oil and gas export in the GDP in the mentioned countries is shown in fig. 1.

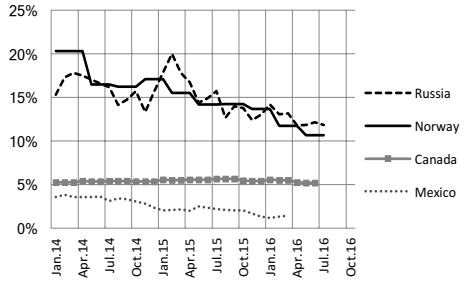

Figure 1: The share of oil and gas export in the GDP structure, %

Source: calculated based on the data of Federal Service of State Statistics (Rosstat) and state statistical agencies of Norway, Canada and Mexico

The simultaneous decline of this indicator in the group of countries considered and the fall in oil prices starting from the middle of 2014 is obvious.

One can notice that the oil and gas export in the GDP structure gained an even more prominent role in Russia than in Norway over the past two years. If, at the beginning of 2014, oil and gas export made up 20% of the Norwegian economy, in the middle of 2016 this indicator fell to 10.7%. As for Russia, within the same period the share of oil and gas export declined from 15% to 11.8%.

Russian oil exporters strive to compensate the income lost due to the decline in oil price by escalating the volumes of production and sales. Norway is unable to take similar steps due to specific characteristics of their fields [Glazyev 2015, pp. 21-59].

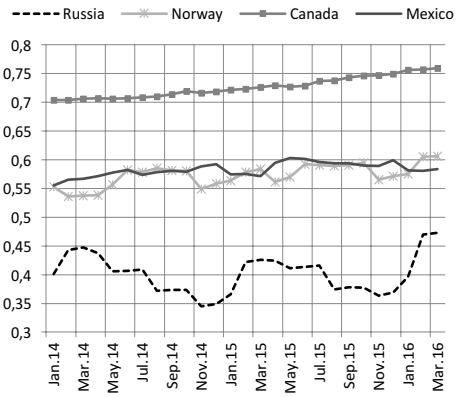

Figure 2: The level of monetization in the economies of Russia, Norway, Mexico and Canada (M2/GDP).

Source: made on the basis of the data provided by the Bank of Russia, Bank of Canada, Bank of Mexico, Bank of Norway

The level of monetization in the economies considered behaves in the following way in terms of basic money aggregate M2 (fig. 2). The most volatile monetization dynamics is observed in Russia, which was determined by severe fluctuations of the exchange rate during the period considered, as compared to the same indicators in other countries under study. Only starting from the middle of 2016 the ruble's volatility got back to normal parameters typical for most floating "commodity currencies".

Among the countries considered the most stable monetization dynamics are observed in the Canadian economy, which is now characterized by the upward trend. Its gradual growth from 0.7 to 0.76 starting from 2014 can be noticed.

The insignificant fluctuations of monetization level during the same period are observed in Mexico and Norway (in a range between 0.53 and 0.61).

As noted previously, the severest magnitude of monetization fluctuations in terms of M2 aggregate/GDP is typical for Russia. Since the beginning of 2014 four successive trends have been observed in the monetization dynamics in Russia:

1) decline from 0.45 to 0.34 within the period from February to November 2014;

2) growth from 0.34 to 0.42 within the first quarter of 2015;

3) decline from 0.42 to 0.36 within the period from the second quarter of 2015 to the beginning of 2016;

4) Growth from 0.36 to 0.47 starting from the beginning of 2016.

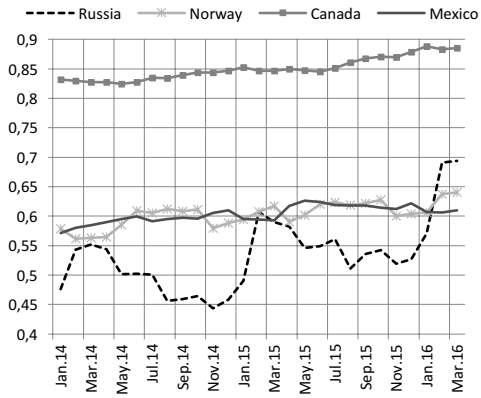

Figure 3: Monetization level in the economies of Russia, Norway, Mexico and Canada (M2x/GDP).

Source: made on the basis of the data provided by the Bank of Russia, Bank of Canada, Bank of Mexico, Bank of Norway

Equally sizable fluctuations of the monetization level of the Russian economy are typical for the M2x/GDP aggregate as well (fig. 3.3), as the foreign currency denominated accounts in commercial banks are also taken into consideration in it, apart from the traditional money aggregate M2. Tellingly, it was this indicator in terms of which Russia outranked Mexico and Norway in 2016.

The observed monetization leap means a substantial increase in the investment potential accumulated in the Russian banking system. It turns out that the currency re-evaluation became a key factor of the positive dynamics of the Russian economy's general monetization. But if we consider the economy's monetization without foreign currency deposits, we will see that the Russian economy is still characterized by sub-monetization and closes the four countries considered with the M2/GDP indicator at the level of 0.48.

The change in monetization dynamics trends took place during the same time periods, but the magnitude of fluctuations in terms of different aggregates varies significantly, especially in Russia.

If in other countries there is almost no difference in the fluctuations of the monetization level, depending on the choice of a numerator indicator in the monetization formula, in Russia it was important due to the exchange rate fluctuations and high interest rates (fig. 4).

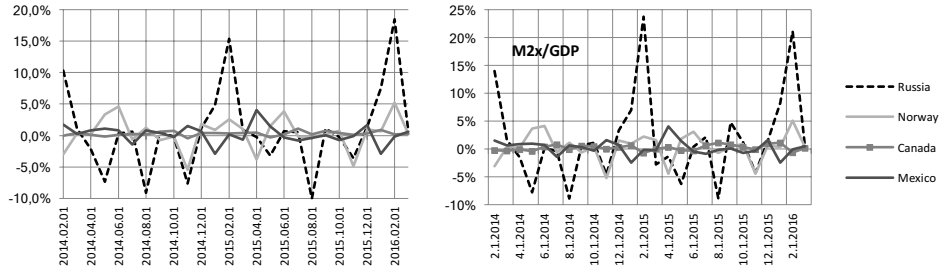

Figure 4: The magnitude of monetization level fluctuations in the economies of Russia, Norway, Mexico and Canada

Source: made on the basis of the data provided by the Bank of Russia, Bank of Canada, Bank of Mexico, Bank of Norway

Figure 5 shows the dynamics of the money aggregates M2x/M2 ratio by countries considered. Its notable growth in Russia along with neutral dynamics in Canada, Mexico and Norway is obvious.

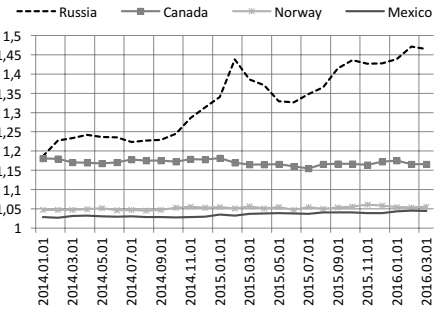

Figure 5: M2x.M2 ratio in Russia, Norway, Mexico and Canada.

Source: made on the basis of the data provided by the Bank of Russia, Bank of Canada, Bank of Mexico, Bank of Norway

Such significant fluctuations of Mx2/M2 ratio in Russia reveal that the level of foreign currency predominance on the bank accounts is such that it immobilizes a significant part of financial resources required for its development. Put simply, the currency is allocated abroad by the Russian banks and not converted into loans in the domestic market.

For the Russian exporters it is no use attracting foreign currency debt funding from the Russian banks. The crediting of resources industries is quite insignificant in Russia. As for the foreign currency lending to the importers, it has been in decline lately due to general economic stagnation and lowered consumer activity.

At the end of 2011, the growth of the Russian economy started slowing down. Along with that another wave of converting the assets of Russian firms and households into foreign currency began. Consequently, for 2.5 years the foreign currency accounts of the legal entities increased from USD 100 billion to USD 193 billion by the middle of 2014. Afterwards their growth stopped and started to decrease gradually to reach the actual USD 167 billion. The increment rate of foreign currency accounts of natural entities turned out to be more inertial and stable. At the present moment the foreign currency denominated assets of natural entities in banks amount to the estimated USD 93 billion (fig. 6).

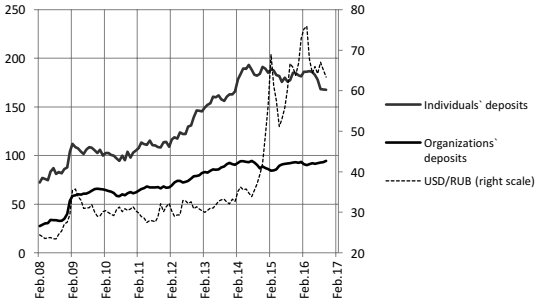

Figure 6: The dynamics of foreign currency accounts (USD billion) in Russian bank system and USD/RUB exchange rate

In contrast to the crisis of 2008-2009, the ruble exchange rate fluctuations did not have a significant impact on the behaviour of commercial bank depositors. A substantial fall of the ruble exchange rate did not trigger rapid conversion of the households' assets into foreign currency, and the firms partially locked in the profits derived from the generated foreign exchange gain.

But after relative stabilization of the ruble in 2016 no conversion of households' assets back into ruble is being observed, which is seen as an adverse factor. People still keep a substantial share of their bank savings in foreign currency and they do not seem to want to change their preferences.

As for the firms, their balance of foreign currency denominated bank loans and foreign exchange deposits in the Russian banking system drifted to the latter. As fig.7 shows, from the beginning of 2013 it left the negative values area and passed to the positive values area, which can be interpreted as the surplus of foreign exchange accumulations possessed by legal entities in relation to the foreign currency denominated indebtedness.

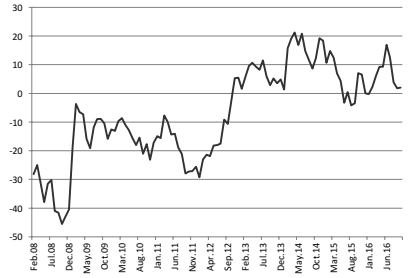

Figure 7: Dynamics of foreign currency accounts (USD billion) in Russian banking system and USD/RUB exchange rate

Over the last years, the Bank of Russia almost did not interfere in the processes of the conversion of assets into foreign currency in the banking sector. There are only restrictive regulations in respect of a permissible open currency position of a particular commercial bank stipulated by the Bank of Russia Instruction No 124-*И* dd. "On the volumes (limits) of open currency positions, their calculation methodology and special aspects of carrying out control over the credit institutions in terms of compliance with them". In accordance with this document, the daily sum of all long (short) open currency positions in certain foreign currencies and certain precious metals should not exceed 20% of the own funds (capital) of the credit institution. Any long (short) open currency position in certain foreign currencies and certain precious metals as well as the balance position denominated in rubles should not exceed 10% of the own funds (capital) of the credit institution on the day-to-day basis.

These are quite severe restrictions that do not allow bankers to convert foreign exchange deposits into rubles and allocate them in assets denominated in Russian currency. Theoretically, the ruble hedging transactions can be carried out in the forward market. However, the tightness of this market in Russia and costliness conditioned by a substantial interest rate gap between ruble denominated deposits and foreign exchange deposits do not allow the banks to apply this tool to the full extent.

However, Russian banks do not tend to maintain the negative currency position even with due account for the limit of balance position in respect of the ruble. Figure 8 shows the calculated data in respect of the open currency position indicators in the banking system of Russia from 2009 to 2016 in general. Throughout the whole period there was not a single day when the open foreign exchange position in the banking system of Russia had a negative value.

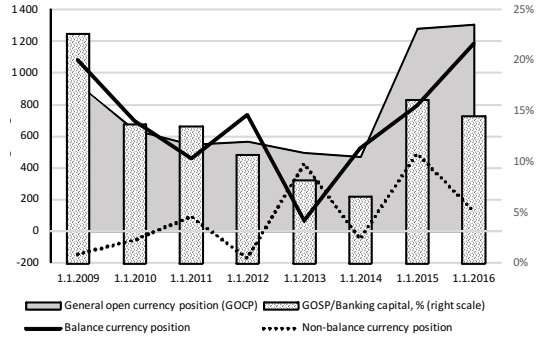

Figure 8: Dynamics of indicators of the open foreign exchange position in the Russian banking system

It can be seen from figure 8 that from the beginning of 2013 the volume of the balance long open currency position in the banking system grew from an almost neutral level of RUB 66 billion to RUB 1.2 trillion.

This means that commercial banks made a bid for the fall of the ruble market value, as the long foreign exchange position is profitable for the banks in case the national currency depreciates, which was exactly what happened in the following years.

The model of the economic agents' behaviour in Russia has always been different from the behaviour of similar agents in countries with the floating exchange rate regime, which has been caused by the fact that over the last 25 years legal and natural entities have been living in expectation of a sudden weakening of the national currency caused by external factors. It

can be noted that such psychology of the agents has been formed in almost all countries dependent on the raw materials export where the hybrid exchange rate regime was maintained. On the one hand, there was no systemic trust to the national currency; on the other hand, the monetary regulation authorities were incapable of securing long-term stability of the exchange rate. The long-term weakening trend after 2 or 3 years of a relatively stable national currency with a narrow range of fluctuations initially contributed to the opening of the short national-currency positions by banks and individuals.

It was particularly typical for such countries as Russia, Kazakhstan and Azerbaijan. In these countries the Central Banks tended to target the exchange rate within narrow bands. This was done quite successfully in the favourable commodity prices environment. The regulating authorities bought an increasing flow of foreign exchange revenue from the market, thus replenishing the international reserves. However, with the oil prices decline, these countries proved unable to withstand the speculators' pressure and the national currencies exchange rates were allowed to weaken.

Unfortunately, the period of adaptation to the new exchange rate regime in Russia coincided with a cycle of drops in energy prices, which confirmed the general lack of the economic agents' trust to the ruble. In any case, there were no widespread closures of short open currency positions in respect of the ruble.

From our point of view, a substantial period of floating of the Russian national currency should pass, so that the absence of the regulating authority in free trading would ensure its fluctuations in both directions. As a consequence, having an expressly short position in respect of the Russian currency will be disadvantageous for the economic agents due to the uncertainty of the future scenarios. Eventually the model of the economic agents' behaviour in Russia is going to be analogous to the one in Norway and Canada, where even under the conditions of severe fluctuations of the national currency, there are no sizable fluctuations of money aggregates and the economy's monetization level.

In case the inflation in Russia decreases to the target level and this result is maintained in the longer term, it is very likely that the stability in the behaviour of the economic agents will be attained. An impediment to these plans can be a high degree of the economy's monopolization, the absence of structural economic reforms and high dependence on international market price shocks in respect of the energy supplies.

7. Suggestions

The authors' suggestions in respect of limiting the capital outflow are as follows:

1. Tightening the restrictions in respect of long foreign exchange positions by the level of 5% of the capital, with a stable level of permissible short foreign exchange position of 10% from the bank's capital;

2. Gradual withdrawal of foreign exchange deposits from the effect of the law "On insurance of the bank deposits". For example, it is necessary to conserve the provisions of this law in respect of the existing foreign exchange deposits of individuals, but it should be abolished for the newly established foreign exchange deposits starting from a certain moment in the future. In this case, the depositor will either withdraw the remaining money from the account or convert it into rubles and allocate it on bank deposits in rubles with corresponding security guarantees.

3. To continue increasing the gap between the minimum reserves requirements for bank deposits in Russian and foreign currency. Starting from August 2016 this gap makes two percentage points. It is advisable to drive the reserve requirements in respect of foreign currency deposits from the current 7% to the maximum values stipulated by the law "On the Central Bank of the Russian Federation" (20%). In this case banks will be forced to weaken the long open foreign exchange position, since maintaining it will be unprofitable, as well as to impair several-fold the conditions of keeping deposits in foreign currency for the customers.

8. Discussions

The foreign exchange regulation should be considered in two aspects. On the one hand, the regulating authority should define the regulatory constraints for carrying out foreign exchange operations; on the other hand, it should establish the national currency exchange rate regime against other currencies.

There are many ways to transfer the capital, with the main being as follows: fictive export, securities market, insurance, construction and erection works, consulting, marketing and transport services, etc. The scale of Russia's capital outflow is counted in tens of billions of U.S. dollars per year. However, the discussion about the liberal foreign exchange policy in Russia was closed in the mid-2000s and there are no restrictions in respect of the cross-border capital movement.

In this regard searching for an efficient combination of regulatory and limiting constraints

in respect of the percentage of foreign currency denominated assets and liabilities in bank balance sheets and increasing the investment attractiveness of the national security market tools is a key factor of the stability of the financial account of the country's balance of payments. The latest data revealing a dramatic decrease in the capital outflow from Russia under the financial account of the balance of payments are indicative of taking the right steps in this direction.

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Methods of decision making supporting state regulation of crop production development in the regions of Ukraine

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ABSTRACT

This article deals with the prospects and trends of crop production development in Ukraine, as well as the methods and ways of supporting this industry by the state. According to the article, the primary objective of the state is to create conditions through the reallocation of resources and facilitate the introduction of new forms of economic activity in the regions, which are depressed in terms of agriculture today. It is noted that to justify the need for institutional changes in crop production we must take into account the appropriate specifics of agricultural production in some areas. The article reports that, a large number of similar types of agricultural enterprises, unlike in other sectors of the economy, allow us to group the results of their activity: in terms of forms of management, on a territorial basis or according to other types of features for further comparative analysis. Therefore, the article offers the crop production regions clustering in certain areas, to determine which areas need the state aid priority. It is noted that in terms of crop production it is possible to increase the efficiency of agricultural activity due to a better use of agricultural land, as well as by an increase in average crop yield per 1 hectare. Therefore, it is offered to use the integral index of crop production position of each region, based on the ratios of extensive and intensive load. The extensive load factor represents the degree of agricultural land use.

The intensive load factor reflects the effectiveness of land fund usage, that is, the average yield, which is produced from the agricultural land of the same region. However, the average yield cannot directly serve as the basis for calculation, because the structure of the sown area of each region is heterogeneous. In this study, while calculating the intensive load factor, it is offered primarily to carry out the procedure of yield rate normalization for each group of crops separately.

Using the method of integral estimation of crop development, the autor has made an appropriate ranking of Ukraine regions according to the area of sown crops in Ukraine, based on which 4 sectors of Ukraine areas have been allocated and grouped by crop production development level. The article goes on to give the recommendations for decision making supporting investments and state aid for each of the selected sectors to further develop crop production in the regions of Ukraine.

Keywords: crop production, regions clustering, estimation of plant growing, intensive load factor, crop capacity.

1. Introduction

The development of institutional direction in modern economic science has become an objective response to the systematic failure of the economic mechanism, dysfunction of market institutions, as well as the ideological crisis of the society. The national economy provides for appropriate social and economic institutions through which it is concretized and adapted to reform [Obozna 2014].

The agricultural sector plays a major role in the Ukrainian economy. Ukraine has approximately 43 million hectares (ha) of agricultural land, including 32 million ha of arable land, an area equivalent to one third of the arable land in the European Union (EU). Half of it is black soil, the highest productive soil type in the world and a commodity in such demand that an illegal market has developed in selling it [OECD Eurasia 2015].

It is a fact that some transnational agribusinesses are increasingly investing in Ukraine, including Monsanto, Cargill, and DuPont. The named corporations are taking over all aspects of Ukraine's agricultural system [The Oakland Institute 2014].

Thus, a general assessment of the agricultural sector and rural areas is crucial for the development of proper strategies and policies [FAO 2012].

Although the essence of the agricultural sector performance analysis and institutional reforms modeling to ensure the competitiveness of the agro-industrial complex of the country has much in common with other sectors of the economy, the specifics of agriculture have some features to consider. These include:

1. The results of the agribusiness activities have a strong dependence on climatic con-

ditions of the geographical area. Therefore, taking into account the significant territorial area of farmland in Ukraine and its geographic location, it is appropriate to divide the whole territory of Ukraine into different areas, which are connected to each other by some common existence conditions, for example, the administrative characteristics.

2. Areas of agriculture in any country are characterized by a vivid production seasonality, with a period of one year. Consequently, there is uneven use of labor, non-current and current assets, for example, some types of agricultural machinery are used only 20-30 days a year.

Thus, a long period of the production cycle with the uneven use of the resources and capital in agriculture leads to the fact that the full analysis of the results of the activities must be performed on the result of the entire year. Also when we are building models for the agricultural sector of the country, it is advisable to use a discrete type models, where the simulation period is one year.

3. As farming deals with living organisms, its level of development is influenced not only by economic factors, but also by biological and physico-chemical properties and laws. This significantly complicates the predictability of the industry and the assessment of impact factors on the formation of the final result.

Therefore, unlike traditional industries, related with material and non-material production, where the economic results are well described by mathematical economic models, the agricultural sector is characterized by a high degree of uncertainty.

This leads to the fact that by using economic and mathematical models, based on the scenario approach, we can provide only general advice on the management of the sector. However, it is almost impossible to calculate the final result of the agricultural sector activities during the year with an acceptable level of accuracy.

4. The main production resource is agricultural land, the performance of which (crop yield) is not the subject to the exact calculation. In addition, with a proper use, including the implementation of a complex of agro-technical actions, this resource cannot be worn out, and it is also able to increase its productivity.

We also know that in industry it is possible to produce certain products by using a certain type of equipment. Land in this case is a versatile production factor: it can be used for the cultivation of any crops. In terms of economic and mathematical modeling it means high mobility for growing different kinds of crops.

5. A large number of similar types of agricultural enterprises, unlike in other sectors of the economy, allow us to group the results of their activity: in terms of the forms of management, on a territorial basis or according to other types of features for further comparative analysis.

2. Literature review and the problem statement

The reasons for the insufficiency of the agrarian reforms efficiency and opportunities for improving the agriculture of Ukraine are actively studied by national and foreign scholars, including: Lendel [2001], Golyan [2006], Revenko [2011], Sabluk [2011], Skidan [2010], North [1991], Makarenko [2006], Sigg [2014], Van Leeuwen et al. [2012], Van Winden [2013], Visser et al. [2011], Warner et al. [2008] and others.

To justify the need for institutional changes in crop production we must take into account the appropriate specifics of agricultural production in some areas. The development of crop production in Ukraine is not homogeneous in its quality. Therefore, the primary objective of the state is to create conditions through the reallocation of resources and facilitate the introduction of new forms of economic activity in the regions, which are depressed in terms of agriculture today.

The aim of the article. Thus, we are faced with an important, scientific problem of the assessment of crop production development, clustering in certain areas, determining which areas need the state aid priority, and giving recommendations for decision making supporting the investment and institutional changes for each of the selected sectors to further develop crop production in the regions of Ukraine.

3. Research results

The prerequisites for such a generalizing evaluation are as follows:

1. The result of any economic activity depends on quantitative (extensive) and qualitative (intensive) factors. The quantitative factors require attraction of additional resources, and the quality factors – a more efficient use of available resources. In terms of crop production to increase the efficiency of agricultural activity can be due to the better use of agricultural land, as well as by an increase in average crop yield per 1 hectare. Therefore, an integral indicator of the crop production of each region should be based on the ratios of extensive and intensive load. In order to be able to ensure the comparability of the results, these factors should be normalized from 0 to 1. Thus, the integral index of the crop production of each region will be calculated by the formula:

$$K_i = k_{\text{i,екс}} \times k_{\text{i,інт}}, \quad (1)$$

where K_i- integral index of the *i*-region development of plant cultivation;
$k_{\text{i,екс}}$ - extensive load factor of the *i-th* region;
$k_{\text{i,інт}}$ - intensive load factor of the *i-th* region.

The conditions for rationing should provide that the best coefficients of the extensive or intensive load are when they are closer to 1, and vice versa. With this limitation, our target indicator will also take the values from 0 to 1.

2. The extensive load factor represents the degree of the agricultural land use and is calculated using the formula:

$$k_{\text{i,ext}} = \frac{S_{\text{i,П}}}{S_{\text{i,у}}}, \quad (2)$$

where $S_{\text{i,у}}$ – area of the available agricultural land in the *i*-region, thou. of hectares;
$S_{\text{i,П}}$– areas of agricultural land which were used in the *i*-region (посівна площа), thou. of hectares.

Since $0 \le S_{\text{i,П}} \le S_{\text{i,у}}$, the extensive load factor $k_{\text{i,ext}}$ will vary from 0 to 1. Larger values of $k_{\text{i,ext}}$ will fit better usage of the land fund for agricultural production.

3. The intensive load factor k_(i,"int") should reflect the effectiveness of land fund usage, that is, the average yield, which is produced from the agricultural land in the i-region. However, the average yield cannot directly serve the basis for calculating k_(i,"\int"), because the structure of the sown area of each region is heterogeneous. The available data from statistic reports concerning the production of agricultural crops in different regions are grouped in the following main types of crops:

- grains and legumes;
- technical culture;
- potatoes, vegetable-melon crops;
- forage crops.

Each of these groups has its own crops and the highest possible average annual yield. For example, the yield of the potato and vegetable--melon crops, according to the statistics, is 4-6 times higher than the yield of the grain and leguminous crops, provided that the other conditions are equal (tonnes / ha). Therefore, if in one region a cultivated area in the first type of crop which occupies the largest share, and in another area its the second type of crop, comparing them with each other in terms of an average yield is incorrect.

In this study, calculating the intensive load factor k_(i,"\int") is offered, primarily to carry out the procedure of yield rate normalization for each group of crops separately. To do this we offer conventional symbols. Let the matrix of acreage be S, the volume of crop production be Q, and productivity be Y, the calculations are as follows:

$$S = \begin{vmatrix} s_{11} & s_{12} & \dots & s_{1m} \\ s_{21} & s_{22} & \dots & s_{2m} \\ \dots & \dots & \dots & \dots \\ s_{n1} & s_{n2} & \dots & s_{\text{nm}} \end{vmatrix}; \quad Q = \begin{vmatrix} q_{11} & q_{12} & \dots & q_{1m} \\ q_{21} & q_{22} & \dots & q_{2m} \\ \dots & \dots & \dots & \dots \\ q_{n1} & q_{n2} & \dots & q_{\text{nm}} \end{vmatrix}; \quad Y = \begin{vmatrix} y_{11} & y_{12} & \dots & y_{1m} \\ y_{21} & y_{22} & \dots & y_{2m} \\ \dots & \dots & \dots & \dots \\ y_{n1} & y_{n2} & \dots & y_{\text{nm}} \end{vmatrix} \quad (3)$$

where s_{ij}, q_{ij} та y_{ij} – accordingly, sown area, the volume of crop production and average yield of *j*-th of crops and the *i-t*h region.

The columns of considered matrices characterize the value of targets in each area for j-th groups of crops. Matrix lines - value targets for each group of crops in i- th region.

Matrix S and Q are incoming and are formed according to the annual state statistical reporting. Accordingly, the matrix Y elements are calculated based on the following formula:

$$y_{\text{ij}} = \frac{q_{\text{ij}}}{s_{\text{ij}}}, \quad (4)$$

For the next calculation of the integral indicator crop development in each area, we perform normalization of matrix Y elements, using the following formula:

$$\overline{y_{\text{ij}}} = \frac{y_{\text{ij}}}{\max\limits_{i}(y_{\text{ij}})}, \quad (5)$$

That is, first we find the maximum yield value for each column of the matrix Y, and then divide on them each element of the matrix. The result is a matrix of normalized yield values ¯Y, where for each j-th group of crops normalization was done separately. That is, each column of the matrix ¯Y takes values from 0 to 1. Moreover, the normative value 1 is the region with the highest yield in Ukraine from this group of plants. So we neutralize the fact that different groups of crops have different values of the maximum yield, and therefore the area with different structure of acreage could not be compared with each other.

Then, the intensive load factor k_(i,"\int") according to a weighted arithmetic mean formula takes the form:

$$k_{\text{і,інт}} = \frac{\frac{\sum_{j=1}^{n} \overline{y_{\text{ij}}} \times \text{пв}_{\text{ij}}}{\sum_{j=1}^{n} \text{пв}_{\text{ij}}}}{1} = \frac{\sum_{j=1}^{n} \overline{y_{\text{ij}}} \times \frac{s_{\text{ij}}}{\sum_{j=1}^{n} s_{\text{ij}}}}{1}, \quad (6)$$

where пв_{ij} – the proportion of cultivated area *j-th* crop and a *i-th* region.

Substituting formula (2) and (6) (1), we get the final view of the integral index of the plant industry development in the i-th region:

$$K_i = k_{i,\text{екс}} \times k_{i,\text{інт}} = \frac{S_{i,II}}{S_{i,V}} \times \frac{\sum_{j=1}^{n} \overline{y_{\text{ij}}} \times \frac{s_{\text{ij}}}{\sum_{j=1}^{n} s_{\text{ij}}}}{1} = \frac{S_{i,II}}{S_{i,V}} \times \frac{\sum_{j=1}^{n} \left(\frac{y_{\text{ij}}}{\max_i (y_{\text{ij}})} \times \frac{s_{\text{ij}}}{\sum_{j=1}^{n} s_{\text{ij}}} \right)}{1}, \quad (7)$$

Depending on the values we can perform a ranking of the regions of Ukraine in terms of crop development considering the extensive and intensive factors; thus:

– on the one hand, the indicator assesses the level of acreage usage which is in our possession;

– on the other hand, the indicator also takes into account the efficiency of their use due to the reduced weighted average yield.

Using the method of integral estimation of crop development, we will make an appropriate ranking of Ukraine regions according to the area of sown crops in Ukraine, and calculate the value of the extensive load factors, i.e the percentage of agricultural land usage. This coefficient fluctuates within a range between 47.33% (Zakarpattia Oblast) and 93.39% (Kirovohrad Oblast). Ukraine's average percentage of agricultural land use is 78%.

The extensive load factor on a territorial basis is not proportional due, primarily, to the differences in climatic conditions, existing infrastructure, financial resources and material, technical equipment of agricultural enterprises. At the same time many regions of Ukraine have significant reserves to improveme the indicator. Among them there are such areas as: Zakarpattia Oblast, Luhansk Oblast, Lviv Oblast, Volyn Oblast, Zhytomyr Oblast, Chernihiv Oblast, Chernivtsi Oblast, Rivne Oblast etc. The percentage of using their farmland does not exceed 70%.

The leaders of using the agricultural land are Mykolaiv Oblast, Vinnytsia Oblast, Dnipropetrovsk Oblast, Cherkasy Oblast, Poltava Oblast and Kirovohrad Oblast with the index exceeding 88%.

The elements of the matrix Y have been calculated according to the formula 4 in Table. 1. In addition, table 1 shows, the maximum average yield for each group of crops, which are necessary for the normalization procedure.

As can be seen, the average yield in Ukraine, the maximum and minimum yield in areas for different crops are as follows:

– grains and legumes - 4.31 tonnes / ha to 6.2 tons / ha in Sumy region and 2.73 tonnes / ha in the Zaporozhye region;

– technical cultures - 3.33 tons / ha against 10.63 tonnes / ha in Ternopil region and 0.72 tonnes / ha in Kherson region;

- potatoes, vegetables and melons - 18.83 tonnes / ha against 23.56 tonnes / ha in the Khmelnitsky region and 11.19 tonnes / ha in the Luhansk region.

These data show that the maximum yields per hectare for different crops are in northwestern Ukraine, and the reduced productivity – in the southeastern part of the country. This is because the South-East of Ukraine belongs to the zone of risky agriculture, primarily because of the high probability of dry weather and lack of irrigation of agricultural land. In addition, the zone of the antiterrorist operation in the Luhansk and Donetsk regions also adversely affect the agricultural development of these areas.

To calculate the intensive load factors, normalized values of the yield were found together with the proportion of cultivated areas of the j-th type of crops in the i-th region. Within each crop, the indicator can take the values from 0 to 1. Based on the calculation of the normalized value of the maximum yield for each crop, they have been brought to a comparable form.

Table 1: Average crop yields in 2014 in areas, tonnes / he

Oblast of Ukraine	Including			
	grains and legumes	technical crops	Potato, vegetable and melon	forage crops
Ukraine	4.31	3.33	18.83	13.22
Vinnytsia Oblast	6.03	7.54	21.00	19.15
Volyn Oblast	3.81	9.51	17.72	8.65
Dnipropetrovsk Oblast	2.83	1.73	16.21	10.46
Donetsk Oblast*	3.32	1.72	15.40	9.22
Zhytomyr Oblast*	5.07	3.66	22.05	10.24
Zakarpattia Oblast	3.85	1.11	22.11	5.91
Zaporizhia Oblast*	2.73	1.29	15.01	7.87
Ivano-Frankivsk Oblast*	4.80	3.74	16.02	10.97
Kiev Oblast*	5.97	4.66	19.86	15.39
Kirovohrad Oblast	4.34	2.35	13.34	13.42
Luhansk Oblast*	2.97	1.53	11.19	4.99
Lviv Oblast*	4.68	8.94	19.14	9.73
Mykolaiv Oblast*	3.02	1.70	19.32	11.19
Odessa Oblast	3.09	1.82	17.36	11.56
Poltava Oblast	5.06	4.52	21.24	18.13
Rivne Oblast	4.72	6.48	20.42	10.72
Sumy Oblast	6.20	1.88	21.44	18.88
Ternopil Oblast	5.48	10.63	21.59	19.02
Kharkiv Oblast*	4.47	3.94	18.64	14.21
Kherson Oblast*	2.79	0.72	18.00	8.43
Khmelnytskyi Oblast*	6.01	6.94	23.56	15.38
Cherkasy Oblast*	5.79	3.94	16.03	19.52
Chernivtsi Oblast*	5.25	1.91	21.55	10.43
Chernihiv Oblast*	5.61	2.50	19.20	14.68
Maximum productivity	6.2	10.63	23.56	19.52

Source: www.ukrstat.gov.ua.

According to the calculations, the sown area based on the ex ample of the Vinnitsa region was distributed as follows:

– grains and legumes – 52%;
– technical culture- 32%;
– potatoes, vegetables and melon – 8%;
– forage crops – 9%.

Finally, the integral index of crop development has been calculated in each area; tab. 2:

According to this integral indicator, the authors have carried out a procedure of ranging areas, column (5). Better values correspond with lower ranks, and vice versa.

As we can see, among the leaders in the development of crop in Ukraine are the Vinnytsia, Ternopil and Cherkasy region. At the same time, Lugansk, Zaporozhye and Kherson regions have the worst indicators of value, compared to other regions.

In addition, table 2 contains the data on the average value of factors for the entire Ukraine. These values of factors may make a starting point of reference for the classification of areas according to the development of crop production. A graphic idea of this may be obtained from figure 1.

Table 1: Average crop yields in 2014 in areas, tonnes / he

Oblast of Ukraine				Rank
1	2	3	4	5
Ukraine	0.780	0.583	0.454	–
Vinnytsia Oblast	0.883	0.885	0.781	1
Volyn Oblast	0.641	0.643	0.413	16
Dnipropetrovsk Oblast	0.886	0.376	0.333	19
Donetsk Oblast*	0.750	0.413	0.310	20
Zhytomyr Oblast*	0.646	0.641	0.414	15
Zakarpattia Oblast	0.473	0.607	0.287	21
Zaporizhia Oblast*	0.763	0.321	0.245	23
Ivano-Frankivsk Oblast*	0.763	0.639	0.488	9
Kiev Oblast*	0.763	0.765	0.584	6
Kirovohrad Oblast	0.934	0.476	0.444	13
Luhansk Oblast*	0.496	0.330	0.164	24
Lviv Oblast*	0.621	0.741	0.460	12
Mykolaiv Oblast*	0.882	0.390	0.343	18
Odessa Oblast	0.839	0.422	0.354	17
Poltava Oblast	0.933	0.705	0.658	4
Rivne Oblast	0.687	0.709	0.487	10
Sumy Oblast	0.754	0.766	0.577	7
Ternopil Oblast	0.831	0.920	0.765	2
Kharkiv Oblast*	0.793	0.620	0.492	8
Kherson Oblast*	0.806	0.337	0.272	22
Khmelnytskyi Oblast*	0.758	0.845	0.641	5
Cherkasy Oblast*	0.914	0.747	0.683	3
Chernivtsi Oblast*	0.686	0.631	0.433	14
Chernihiv Oblast*	0.649	0.731	0.475	11

Source: by the authors

The dotted line in figure 1 indicates calculated values for the whole Ukraine. Accordingly, we can distinguish 4 sectors, which are characterized by the following features:

- sector I - the most successful region in Ukraine in terms of crop production development. As for the indicator of using the available agricultural land, and on the weighted normalized level of productivity, the level is a higher than the average in Ukraine. The first sector includes: Vinnytsia, Ternopil, Cherkasy, Poltava and Kharkiv regions. The recommendations for the state regulation of the institutional change is the full cooperation of market relations development in the sphere of production, supply and marketing of agricultural products; prevent monopolization of the market and so on.

- sector II - its composition includes the same region with high yield, Khmelnytsky, Lviv, Sumy, Kiev, Chernigov, Rivne, Zakarpattia, Zhytomyr, Volyn, Chernivtsi and Ivano-Frankivsk regions. However, the level of usage of the existing farmland in this case is substantially inferior to the average Ukraine index. This applies particularly to Zakarpattia, Lviv, Zhytomyr and Volyn regions. Public policy regulation in the field of institutional changes should be focused on attracting additional investment resources to the industry, expansion of production and promotion of small and medium businesses.

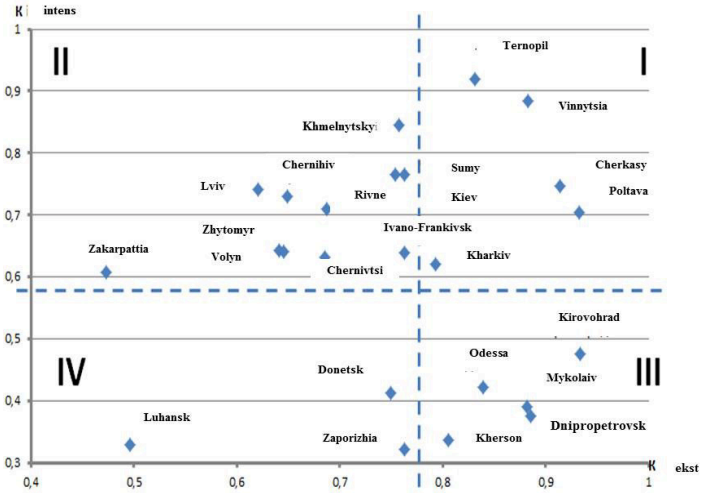

Figure 1: Classification of the regions of Ukraine according to the crop growing development
Source: by the authors

- sector III - characterized by a high level of usage of the available land resources; however, the level of productivity is lower than the average in Ukraine. These criteria are inherent in Kirovograd, Odessa, Mykolaiv, Dnipropetrovsk and Kherson regions. Particular attention should be paid to Kherson and Dnipropetrovsk regions, where the yield is very low. The state policy in the sphere of agriculture should be focused primarily on the study of the causes of the low productivity in the regions. Soil fertility can be improved by reducing the load on the ground efficiently using various types of fertilizers or changing the crops grown. However, the problem of the crop in these areas is the lack of efficient irrigation systems and a dry, hot climate in the summer. Households, farmers and other private enterprises cannot solve this problem on their own because of the lack of investment expenditures and high capital investment required. Therefore, the policy of the institutional changes at the national level should solve this problem by involving public and private investment, long-term development programs, lending entities, etc.

- sector IV - the least successful region in Ukraine for the development of crops. These areas are inferior to other regions both in yield and in terms of useful usage of the available land. Among them are: Lugansk, Donetsk and Zaporozhye regions. Such an objective state of affairs is a reflection of the geopolitical processes taking place in recent years. Governmental steps in institutional changes must be based on a comprehensive development program for agricultural development because it has all the problems of the regions listed above for the regions from sectors II and III.

4. Conclusion

All in all, the article offers a presentation of crop production regions clustering in certain areas to determine which areas need the state aid priority, classifies the condition of each area, formulates recommendations for the urgent institutional changes at the national level. The recommendations for state regulation of institutional changes in the first sector are the full cooperation of market relations development in the sphere of production, supply and marketing of agricultural products; prevention of the monopolization of the market and so on. In sector two, public policy regulation in the field of institutional changes should be focused on attracting additional investment resources to the industry, expansion of production and promotion of small and medium businesses. In the third sector the policy of institutional changes at the national level should solve this problem by involving public and private investments, long-term development programs, lending entities, etc. In sector four governmental steps in institutional changes must be based on a comprehensive development program for agricultural development because it has all the problems of the regions listed above for regions from sectors II and III.

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The efficiency of electric cars for mitigating CO_2 emissions in Poland

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ABSTRACT

This paper concerns the estimation of indirect CO2 emissions associated with the use of electric engines in Poland. The indirect production of exhaust fumes emitted by electric cars is determined by two factors: the engine's power consumption and the volume of the emissions produced when generating power sold by distributors. The current structure of the Polish power system, which is the supplier of the prime mover for electric cars, uses mainly the conventional (high-emission) sources of energy. Thus, using electric cars becomes an indirect cause of the pollution in the atmosphere. Increasing the efficiency of the power production process along with limiting the emission level of the combustion process in conventional power plants is a fundamental and essential solution to reduce air pollution.

Keywords: electric cars, CO2 emission, electric power production, transport development strategy, Polish electric power system.

1. Introduction

The number of passenger cars registered in the European Union rose from 11.9 million in 2013 to 13.7 million in 2015 [ACEA 2016]. The majority of vehicles in the automotive industry are powered by the combustion of petroleum products, such as petrol, diesel fuel, LPG (Liquefied Petroleum Gas), and CNG (Compressed Natural Gas). The 20th century saw the development of alternative power supplies for mechanical vehicles, among them electric engines. According to the French Association for the Development of Electric Vehicles, in 2015 92 693 electric cars were sold, which meant a 61% increase in sales compared to the previous year [Avere France 2015, 2016]. Electric cars constituted 0.46% and 0.68% of all vehicles bought in 2014 and 2015. Statistics show that the electric vehicles market in the EU is still a small but dynamic sector of the automotive industry.

The main reason for the development of electric cars are GHG mitigation provisions included in the energy and climate package. It is estimated that around 10% of GHG emissions is caused by road transport [Ministry of Environment 2015]. One of the primary goals of the Polish Transport development strategy until 2020 (with an outlook to the year 2030) is implementing solutions which would minimize environmental pollution. This means not only improving the efficiency of road freights, but also an increased use of alternative fuels and renewable energy sources in transport. Recommended technologies include the use of hydrogen and fuel cells, natural gas engines, hybrid and electric vehicles. The development should be bolstered by the establishment of a charging and battery replacement station and hydrogen filling station system.

The aim of this paper is to estimate the indirect emissions related to the use of electric engines in Poland. The current structure of Polish electric power system relies mainly on conventional energy sources. Therefore, using electric cars leads to indirect emissions.

The study compares the environmental impact of electric and internal combustion cars. Particular attention has been paid to the following aspects: the unique nature of Polish power production and distribution system, energy consumption, and emission level in the examined cars. The article presents an original methodology of calculating indirect emissions in electric cars which takes into account the area where the energy is consumed.

2. Methodology

The aim of the analysis is to calculate the indirect emissions of gases to the atmosphere. The study covers the emissions of CO2, SO2, NOX and dust. It was based on the so-called Jevons paradox [Sorrell, 2009], which states that in certain conditions, a more efficient use of energy resources leads to an increase in their use and a negative impact on environmental conditions, instead of limiting resource use and improving the state of the environment. The paradox may occur with the use of electric cars if the electric power is obtained from conventional sources.

Determining the value of indirect emissions related to electric cars requires the use of information on energy consumption in electric cars, as well as the emission level for fuels and primary energy sources used to produce electric energy in various regions of Poland. Indirect emission was calculated according to the following formula:

$$indirect\ emission = WE \times ZE$$

where:

WE – GHG emission created in the process of producing electric energy sold by distributors

ZE – average energy consumption in electric cars

To compare the effectiveness of substituting internal combustion vehicles with electric cars, indirect emissions values were juxtaposed with those of conventional cars. Vehicles with similar technical features were used for this purpose. Moreover, the assessment took into account carbon emission standards for new passenger cars [Ordinance no. 443/2009 of 23 April 2009] as well as emission standards for light passenger and commercial vehicles (Euro 6) [Regulation (WE) No. 715/2007 of the European Parliament and of the Council].

3. Data

3.1. Emission related to electric power production in Poland

Most of the electric power produced in Poland is generated in thermal and cogeneration power plants. They burn lignite, hard coal, natural gas, biogas or biomass [Wasiak 2010, pp. 12-13]. During the combustion process, they emit pollutants, such as carbon dioxide (CO2), sulphur dioxide (SO2), nitrogen oxide (NOX) and dust. Apart from the conventional sources, power production in Poland also uses water, wind and solar power.

The owner and operator of the high-voltage transmission system in Poland is the state-owned Polskie Sieci Elektroenergetyczne SA (PSE Operator SA), while medium and low voltage distribution grids in Poland are owned and operated by 5 electric power distributors: Enea Operator Sp. z o.o., Tauron Dystrybucja SA, PGE Dystrybucja SA, Energa-Operator SA, RWE Stoen Operator Sp. z o.o.

All operators of distribution grids in Poland rely mainly on the sale of power coming from conventional sources (Table 1). This type of power constitutes between 67% (Energa-Operator SA) and 93% (Tauron Dystrybucja SA) of the sales. Renewable sources used for generating electrical energy consist primarily of biomass supplemented with water, wind and solar power.

Fuel structure is not the only determinant of the emission level of power production. The final emission values are affected by the age and efficiency of installations or environmental technologies. These factors cause Energa-Operator SA to emit relatively the largest volume of carbon dioxide and nitrogen oxide (915.63 g and 1.3 g respectively), despite the fact that it uses the largest number of RES to produce electric energy. The lowest volume of carbon dioxide and nitrogen oxide emitted when generating 1 kilowatt hour is produced by PGE Dystrybucja SA (694.99 g and 0.94 g respectively).

Table 1: Descriptive statistics of WIG20 returns in the period from 2.01.2004 to 31.10.2016

Specification	Enea Operator Sp. z o.o.	Tauron Dystrybucja SA	PGE Dystrybucja SA	Energa-Operator SA	RWE Stoen Operator Sp. z o.o.
Number of users [in thousands]	2 205	5 300	5 200	2 900	964
Service area [km^2]	58 192	57 940	122 433	75 000	510
Fuel structure	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
Renewable energy sources	20.48	6.54	13.6	33.23	15.37
biomass	7.75	4.67	6.76	5.64	5.07
water power	2.81	0.36	2.06	4.52	1.3
wind power	9.92	1.44	4.7	23.01	9
biogas	-	0.06	-	-	-
solar power	-	0.01	0.08	0.05	-
Hard coal	42.18	83.61	47.71	31.68	47.14
Lignite	32.04	7.83	31.49	29.59	34.18
Natural gas	2.81	0.79	7.18	2.22	3.22
Other	2.49	1.21	0.02	3.28	0.09
Emission level	**[g/kWh]**	**[g/kWh]**	**[g/kWh]**	**[g/kWh]**	**[g/kWh]**
CO_2	731.6	847.27	694.99	915.63	824.87
SO_2	1.5	1.3	1.4	1.75	3.68
NO_X	1.1	0.99	0.94	1.3	1.12
Dust	0.1	0.069	0.069	0.095	0.08

Source: based on: cire.pl, Enea 2016, Tauron 2016, PGE 2016, Energa 2016, RWE 2016.

3.2. Technical parameters of electric cars

The environmental analysis of electric cars used data from catalogues published by the manufacturers of five electric cars which were best-sellers in Europe from January 2014 to July 2016. The selected models are: Renault Zoe, Nissan LEAF, Tesla S P90D, Volkswagen e-Golf and BMW i3 (Table 2). According to manufacturers' specifications, the energy intensity of electric cars varies between 0.24 kWh/km (Tesla S P90D) and 0.127 kWh/km (Volkswagen e-Golf).

3.3 Distinctive features of internal combustion-powered cars

Each of the selected electric cars was juxtaposed with the one equipped with a combustion engine and exhibiting similar parameters (Table 3). The elements taken into consideration were primarily the size and mass of the vehicle, as well as parameters important for the user: maximum power and maximum torque, maximum speed and acceleration. When it comes to the environmental factors, carbon dioxide emission levels quoted on each manufacturer's website were taken into account. This led to the selection of the following pairs: Renault Zoe and Renault Megane IV (1.5 Energy dCi 90 Hp); Nissan LEAF and Nissan Pulsar Visia 1.5 dCi; Tesla S P90D and Porsche Panamera Turbo; Volkswagen e-Golf and Volkswagen Golf VII Trendline 1.6 TDI; BMW i3 and BMW 1 series 120i .

Table 2. Specification of selected electric cars

Feature	Renault Zoe	Nissan LEAF	Tesla S P90D	Volkswagen e-Golf	BMW i3
Engine					
Max. power	65 kW/88 hp	80 kW/109hp	515 kW/691 hp	85 kW/115 hp	125 kW/170 hp
Max. torque	220 Nm from 250 to 2500 rev/min	254 Nm from 0 to 3008 rev/min	967 Nm from 100 to 3900 rev/min	270 Nm	250 Nm
Max. rotational speed of engine	11300 rev/min	10500 rev/min	16000 rev/min	12000 rev/min	-
Battery					
Capacity	22 kWh	24 kWh	90 kWh	24,2 kWh	18,8 kWh
Other parameters					
Vehicle mass	1468 kg	1474 / 1548 kg	2328 kg	1538 kg	1,195/1,270 kg
Power consumption	0.146 kWh/km	0.15 kWh/km	0.24 kWh/km	0.127 kWh/km	0.129 kWh/km
Max. speed	135 km/h	144 km/h	249 km/h	140 km/h	150 km/h
Acceleration: 0-100 km/h	13.5 s	11.5 s	3.3 s	10.4 s	7.2 s
Zasięg (NEDC)	210 km	199 km	509 km	190 km	190 km

Source: own work based on: renault.com, nissan.pl, zeperfs.com, volkswagen.pl, bmw.pl.

Table 3. Specification of internal-combustion powered cars

Feature	Renault Megane IV (1.5 Energy dCi 90 Hp)	Nissan Pulsar Visia 1.5 dCi	Porsche Panamera Turbo	Volkswagen Golf VII Trendline 1.6 TDI	BMW 1 series 120i
Engine					
Capacity [cm^3]	1461	1461	3996	1598	1598
Max. power [rev/min]	66 kW/90 KM	81 kW/110 KM	404 kW/550 KM	81 kW/110 KM	130 kW/177 KM
Max. torque	220 Nm with 1750 rev/min	260 Nm with 1750-2500 rev/min	770 Nm with 1960 - 4500 rev/min	250 Nm with 1500-3000 rev/min	250 Nm with 1500-4500 rev/min
Parameters					
Mass [kg]	1205	1270-1352	1995	1265	1375
Max. speed [km/h]	175	190	306	179	210
Acceleration:0-100 km/h [s]	13.4	11.5	3.6-3.7	11.9	8.5
Fuel consumption and emissions					
urban cycle [l/100 km]	4.2	4.1	12.8 - 12.9	4.5	6.2-6.7
extra-urban cycle [l/100 km]	3.4	3.3	7.2 - 7.3	3.5	4.3-4.7
combined cycle [l/100 km]	3.7	3.6	9.3 - 9.4	3.8	5.0-5.4
Carbon emission [g/km]	95	94	212 - 214	99	116-126
Fuel type	diesel	diesel	petrol	diesel	petrol

Source: own work based on: renault.pl, nissan.pl, porsche.pl, volkswagen.pl, bmw.pl.

4. Results and discussion

Electric cars manufacturers promote them as thoroughly environmentally friendly vehicles, whose use does not affect GHG emission. Nevertheless, the unique nature of Polish electric power system makes it necessary to consider indirect emission linked to the demand for electric energy which accompanies the growing popularity of new technologies in transport.

According to the estimations (Table 4), indirect carbon emission resulting from electric car use in 2015 reached 88.26 – 219.75 g/km, depending on the car model and power distributor. The indirect emission indicator for SO2 equalled 0.165-0.884 g/km, indirect emission of NOX amounted to 0.12-0.312 g/km, and indirect emission of dust ranged between 0.0088-0.0228 g/km.

For carbon emission, it is possible to compare the indirect emission values with the results of traditional internal combustion cars. A comparison of emission values (Table 5) shows that most of the analysed cars emit less CO2 than their electric counterparts, or else their emission values are similar and depend on the power distributor that supplies the power required to charge the vehicle.

Table 4. Volume of the indirect emissions of GH and dust for selected electric car models in Poland in 2015 [g/km]

Model / Distributor	Nissan LEAF	Renault Zoe	Tesla S P90D	Volkswagen e-Golf	BMW i3
CO_2 emission					
Enea Operator Sp. z o.o.	109.74	106.81	175.58	92.91	94.38
Tauron Dystrybucja SA	127.09	123.70	203.34	107.60	109.30
PGE Dystrybucja SA	104.25	101.47	166.80	88.26	89.65
Energa-Operator SA	137.34	133.68	219.75	116.28	118.12
RWE Stoen Operator Sp. z o.o.	123.73	120.43	197.97	104.76	106.41
SO_2 emission					
Enea Operator Sp. z o.o.	0.225	0.219	0.360	0.191	0.194
Tauron Dystrybucja SA	0.195	0.190	0.312	0.165	0.167
PGE Dystrybucja SA	0.211	0.205	0.337	0.178	0.181
Energa-Operator SA	0.263	0.256	0.420	0.223	0.226
RWE Stoen Operator Sp. z o.o.	0.553	0.538	0.884	0.468	0.475
NO_x emission					
Enea Operator Sp. z o.o.	0.165	0.161	0.264	0.140	0.142
Tauron Dystrybucja SA	0.148	0.144	0.237	0.125	0.127
PGE Dystrybucja SA	0.142	0.138	0.227	0.120	0.122
Energa-Operator SA	0.195	0.190	0.312	0.165	0.167
RWE Stoen Operator Sp. z o.o.	0.168	0.163	0.268	0.142	0.144
Dust emission					
Enea Operator Sp. z o.o.	0.0150	0.0146	0.0240	0.0127	0.0129
Tauron Dystrybucja SA	0.0104	0.0101	0.0166	0.0088	0.0089
PGE Dystrybucja SA	0.0104	0.0101	0.0166	0.0088	0.0089
Energa-Operator SA	0.0143	0.0139	0.0228	0.0121	0.0123
RWE Stoen Operator Sp. z o.o.	0.0120	0.0117	0.0192	0.0102	0.0103

Source: own work.

Considering the structure of power production in Poland and indirect GHG emission, it cannot be clearly determined which type of engine, the internal combustion or the electric one, is more environmentally friendly in Polish conditions. The study implies that in most cases (15 in 25), it was the electric car that emitted more carbon that its internal combustion counterpart. It could be noted the environmental attractiveness of the internal combustion engine decreased more when its power grew significantly compared to a significant increase in the power of the electric engine.

Table 5. Comparison of CO2 emission in electric and internal combustion-powered cars

Electric cars	Indirect CO2 emission in g/km	Direct CO2 emission in g/km	Internal combustion cars
Renault Zoe	107-134	95	Renault Megane
Tesla S P90D	167-220	212-214	Porsche Panamera Turbo
Nissan LEAF	104-137	94	Nissan Pulsar
Volkswagen e-Golf	93-116	99	Volkswagen Golf
BMW i3	90-118	116-126	BMW 1 series

Source: own work.

Furthermore, carbon emission standards for internal combustion passenger cars (135 g/km) [Regulation of the European Parliament and of the Council no. 443/2009] are also met by most electric cars when it comes to indirect emission (Table 6). Cars with a high maximum power and large engine/battery capacity are an exception to this rule. These belong to the luxury cars category.

In case of Euro 6 emission standards, in force since September 2014, the upper limit of nitrogen oxide (NOX) emission is 0.06 g/km for internal combustion cars, and 0.08 g/km for Diesel engine cars. If Euro 6 limits applied also to electric cars, neither of these limits would be met and the cars would not be approved for the Polish market.

Table 6. Indirect CO2 emission in electric cars in Poland

Electric cars	Indirect CO2 emission in g/km
Renault Zoe	0.138-0.190
Tesla S P90D	0.227-0.312
Nissan LEAF	0.142-0.195
Volkswagen e-Golf	0.120-0.165
BMW i3	0.122-0.167

Source: own work.

5. Conclusion

The indirect production of exhaust fumes emitted by electric cars is determined by two factors: the engine's power consumption and the volume of the emissions produced when generating power sold by distributors. A decrease in power consumption could be achieved through improving the efficiency of the electric engine. This condition is difficult to meet because the efficiency of a modern electric engine is very high and exceeds 90%. It is worth noting the efficiency of an internal combustion engine does not exceed 40%.

Methods of limiting exhaust fumes emissions into the atmosphere include improving the quality of fuels used for electric power production, coal cleaning, implementing modern effective combustion technologies and introducing emission reduction technologies [Michalak 2014]. Increasing the efficiency of the power generation process along with limiting the emission level of the combustion process in conventional power plants is a fundamental and essential solution to reduce air pollution.

An effective method of limiting emission is changing the structure of energy mix in Poland. An improvement in the current air quality depends on the increased share of traditional low-carbon technologies and renewable sources in electric energy production.

An improvement in air quality can be achieved via respecting and implementing regulations based on previously approved government strategies. Two key areas include the development and implementation of alternative technologies in vehicle engines and increasing the efficiency of solar power production via the creation of high-efficiency power generation. The expansion of the electric car market depends on, among other factors, the development of infrastructure, especially modernisation of the transmission and distribution system.

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Rozporządzenie (WE) NR 715/2007 Parlamentu Europejskiego i Rady z dnia 20 czerwca 2007 r. w sprawie homologacji typu pojazdów silnikowych w odniesieniu do emisji zanieczyszczeń pochodzących z lekkich pojazdów pasażerskich i użytkowych (Euro 5 i Euro 6) oraz w sprawie dostępu do informacji dotyczących naprawy i utrzymania pojazdów.

Rozporządzenie Parlamentu Europejskiego i Rady (WE) NR 595/2009 z dnia 18 czerwca 2009 r. dotyczące homologacji typu pojazdów silnikowych i silników w odniesieniu do emisji zanieczyszczeń pochodzących z pojazdów ciężarowych o dużej ładowności (Euro VI) oraz w sprawie dostępu do informacji dotyczących naprawy i obsługi technicznej pojazdów, zmieniające rozporządzenie (WE) nr 715/2007 i dyrektywę 2007/46/WE oraz uchylające dyrektywy 80/1269/EWG, 2005/55/WE i 2005/78/WE.

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