HOW DOES NEWS RELATED TO WAR AFFECT THE EXCHANGE RATE IN UKRAINE?

by

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Abstract

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This work is aimed to evaluate strength of the link between violence in Eastern Ukraine and the black market exchange rate's movements. In order to estimate effect of the war we use new data on the black market, violence-related news and structural changes in the NBU's policies. Classical regression analysis and Bayesian inference were applied and both approaches showed a pretty close results which indicates consistency of the findings. Firstly, we found that escalation of the conflict leads to the depreciation of the Ukrainian hryvnia at the black market while its economic impact is lower than the effect of the NBU's decisions. Secondly, the black market suffers from inefficiencies since past dynamics is among the strongest predictors of the future movements and future volatility. Therefore, it implies that quick access to the black market data creates possibilities of the arbitrage.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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LIST OF ABBREVIATIONS

BMA – Bayesian model averaging

FX – foreign exchange

IBFXM – interbank foreign exchange market (the official currency market in Ukraine)

PCA – principal component analysis

PIP – posterior inclusion probability

UAH – Ukrainian hryvnia

Chapter 1

INTRODUCTION

In the period 2014 - 2015, news related to the war in the East of Ukraine dominated the Ukrainian mass media. In the same period, also the dynamics of the exchange rate were widely discussed. Intuitively, there should be a link between news related to the war and the exchange rate, especially between war related news and the black market rates as such news affects the confidence in the local currency. A decrease in confidence is likely to lead to a higher substitution between local and foreign currencies and to a higher demand for more stable assets, especially for US Dollars. This hypothesis about the effect of violence on the exchange market's fluctuations is the main topic of this thesis.

Evolution of the military conflict in Ukraine

The War in Donbass started in Spring 2014 in the form of pro – Russian demonstrations in the Donbass region in Ukraine which consists of Lugansk and Donetsk oblasts. It should be mentioned that terms "pro - Ukrainian" and "pro – Russian" commonly refer to the ethnic or linguistic groups with corresponding preferences. However, in the Donbass region, reasons which are apart from ethnic or linguistic ones may lead to the "pro – Russian" likings among rebels. For instance, trade links with Russia might be the only source of income for particular groups of population (Zhukov, 2015). Following the annexation of Crimea by the Russia, a series of pro – Russian protests took place in the eastern and southern parts of Ukraine which escalated into riots and, further, into military conflict between rebels of Donetsk and Luhansk People's Republics (DPR and LPR), and the Ukrainian government. As a result, heavy metal and coal center of the region

became destroyed and disconnected from the main territory under the Ukrainian government. A first peak in the escalation of the conflict was reached during summer 2014 when battles for Ilovaisk and Novoazovsk took place and which resulted in huge human losses and deterioration of the capital. At the same time, in July 2014 civilian passenger jet, Malaysia Airlines Flight 17, was hit and crashed over the conflict zone. Expanding escalation of the conflict led to the ceasefire process, Minsk I agreement, which was signed on 2014, September 5 in Minsk, Belarus. Even though it was claimed that agreement holds, violations took place frequently and people still got killed. During January 2015 the second local peak in the escalation of the military conflict was reached and heavy fighting were common including the Battle of Debaltseve and the Battle of the Donetsk International Airport. These events resulted in a new ceasefire process, the Minsk II agreement, and bunch of reconciliation measures was signed on 2015, February 12. Implementation of the agreement was rather successful which led to stabilization of the escalation of the conflict in the Donbass region, withdrawal of heavy weaponry from the combat zone and decreased number of violence in general. However, few violations of the ceasefire took place and they seem to be unsystematic, except Battle for Maryinka in June 2015 which reflected into short peak of the violence in the region. Figure 1 depicts evolution of the military conflict in the Donbass region.

Despite the fact that intensity of the military conflict in the combat zone reduced and ceasefire was largely observed, political conflict still remains and Donbass region has been developing into so called "frozen zone" which is very similar to other post – Soviet conflict zones such as Abkhazia in Georgia and Transnistria in Moldova. Future recovery and economic development of the destroyed areas are mostly uncertain which might lead to the long – term negative effect on the economic conditions of the whole Ukraine.

Foreign exchange market and socio – political factors

Various papers demonstrated that empirical models, which describe exchange rate fluctuations only by macroeconomic fundamentals, suffer from omitted variable bias and cannot properly explain exchange rate movements (Engel & West, 2005). Meanwhile, exchange rate changes can be better understood if socio – political determinants, such as politics, civil wars, violence and sanctions are added (Tufte, Lobo, 1998; Dreger et al., 2015). The cornerstone of studies which consider non – economic factors as determinants of exchange rate fluctuations is that the most of them considered well – developed countries where financial instruments are well – known and widely used altogether with healthy market system. However, imperfections related to the financial system and primitive capital markets in developing countries, where a violence takes place (case of Ukraine), would introduce dependencies of the economic indicators on socio – political factors. Moreover, there exists a small body of literature on the link between war events and exchange rate evolution, and this thesis is considered to fill that gap.

Official foreign exchange market had been experiencing severe capital controls imposed by National Bank of Ukraine in 2014 - 2015 which caused sharp increase in the volume of the currency black market (Fig. 2) which became the main trading platform for currencies. Dynamics of various parallel market's indicators such as difference between offered and asked amounts of foreign currencies, bid – ask spread and established premium over official market exchange rates reflect economic agents' assessment of the expected losses in wealth and financial assets as a consequence of military and political conflicts. For that reason, black market data are primary subject of interest in that paper.

At the same time, strong depreciation of the Russian ruble during 2014 and strong economic links are likely to create successive negative spillovers on the most of CIS countries (Stepanyan et al., 2015).

On the one hand, collapse in Ukraine was unwound by escalation of the military conflict in the Donbass region. On the other hand, state of the Russian economy is an instrument for the Russian military support for the rebels in the Donbass region. Dreger et al. (2015) showed that depreciation in Russia is mostly caused by reduced prices on oil. Moreover, unanticipated sanctions influenced the conditional volatility of the determinants including exchange rate of Russian ruble against US dollar and Euro.

Due to that reasons, sanctions imposed on Russia from Western countries and vice versa, and oil prices are the subject of matter in explaining link between an evolution of the foreign exchange rate and military conflict in Ukraine.

Odhuno (2009) and Fielding and Shortland (2005) use both monthly and quarterly data for similar issues which motivated by the averaging of redundant shocks. Dreger et al. (2015) and Huett et al. (2013) use daily data under investigation of Russian and Belarusian markets respectively for foreign exchange. However, under conditions of the massive information flows, high dynamics of the military conflict at the Donbass region monthly aggregation might lead to losing significant patterns in the response link between exchange rate and news. Daily data are going to be used which may show immediate effect from the violence.

This thesis will exam relationship between such socio – political factor as news and exchange rate fluctuations formally – knowing the strength of the impact of war-related news on the exchange rate can be helpful to the financial markets, both to regulators and speculators, as well can be politically or military important – indeed, if there is a strong relationship between the exchange rate and the war, war actions can be used to manipulate the exchange rate.

In order to investigate strength of the link between black market exchange rate and news related to war time-series specification is used where the black market

UAH/US exchange rate serves as a dependent variable. In order to obtain a black market data, I ran a web scrapping script and that will be described in more details in Chapter 4. The data on oil prices come from http://www.eia.gov and official exchange rates, weighted average overnight rate and data related to NBU's foreign currency interventions are derived from the NBU site – www.bank.gov.ua. NBU's decrees and reports provide data for restrictions related to the official exchange market. The metrics for war – related news are taken from Zhukov (2015) which cover period from 2014, Feb 28 till 2015, July 31. Data for sanctions are obtained from Dreger et al. (2015) and range from 2014, Jan 1 to 2015, March 17.

The paper's structure is the next. Chapter 2 reviews the existing literature on exchange rate and civil wars relationship. Chapter 3 looks through the applied methodology, time series specification is reviewed. Chapter 4 describes the data, its sources and issues. Chapter 5 shows main results. Chapter 6 makes conclusions, and goes through possible paths for future work.

Chapter 2

LITERATURE REVIEW

Military conflicts are severe destructive processes which lead to enormous changes in the structure and level of economic performance. Usually destruction, disruption, diversion and dissaving are deemed as the most essential forces on the road to the collapse of the economy during civil wars (Collier, 1998). Literature that examines war – related news and exchange rates is scarce, however, most studies explore impact of the civil wars on the whole economy and fluctuations of the exchange rate in the developed countries due to non – war news. Studies on local violence and exchange rate in the developing countries (Fielding, Shortland, 2005; Odhuno, 2009) are also present.

Military conflicts and economic impact

Not surprisingly, military conflicts have affected economic history throughout space and time. Consequently, economics of war has been attracting attention of researchers for many years. Economists separate short – and long – term effects of military conflicts. The most indisputable short – term effect of the war is inflation and reduced welfare of the people as a result. That was noticed a long time ago in ancient China: "Where the army is, prices are high; when prices rise the wealth of the people is exhausted" (Tzu Sun, c.400 BCE). The story behind the link between war and inflation is quite simple. First of all, since war needs extra funds government has to raise funds and altogether there are three options or their combinations how to do that: borrowing, tax increases and printing money (Goldstein, 2003; Rockoff, 2015). While borrowing gives quick access to the needed funds it also creates wide prospects for the future interest rates increase.

According to Rockoff (2015) governments preferred to avoid interest rates increase due to a number of reasons:

- Firstly, it is possible to draw parallels with subprime mortgages: if you could get only subprime mortgage you clearly signal a market that you are insecure. Consequently, government provides a sign that it performs badly when interest rates which it should pay increase.

- Secondly, people are likely to be aware about possibilities of rising tax burden in the future due to the additional borrowing. At the same time, increasing interest rates will strengthen these fears.

- Thirdly, public and enemies might interpret an increase interest rates as an economic vulnerability. On the one hand, it may decrease public support, on the other hand, it might stimulate enemies.

- And finally, usury has been experiencing suspicion from the public throughout the history. Due to that reason, an increase interest rates would be considered as if taxpayers were robbed by a usurer.

Undoubtedly, it is difficult to increase taxes quickly and, moreover, higher taxes will reveal true costs of the war which in turn will undermine practicability of the war efforts in the public eye. According to that, printing money is likely to be the only reasonable option (Rockoff, 2015). Consequently, inflationary pressure occurs (World War I and II, U.S. Civil War, the Vietnam War and etc.) and it destroys price mechanism as a tool for an efficient allocation of resources. Moreover, war – induced inflation may spread to neutral countries while the strongest inflation occurs in combat zones.

Besides short – term effects, capital stock is destructed intensively during the war times which imposes long – term impact on the output in the economy. According to Collier (1995) capital get destroyed through several processes:

- Agents rationally decrease their savings while waiting for a peace.
- War of attrition occurs between opponents which lead to the destruction of the capital and public wealth.
- Social institutions of the civil society a.k.a. "social capital" decrease which may move society from a trusted equilibrium to an opportunistic equilibrium
- Economic agents are likely to transfer their wealth abroad during the war times.

For instance, output decreased by 24% during the Nigerian civil war and by 13% during the Zimbabwean civil war. Moreover, annual growth rate during the war time was 5% lower, on average, than during the peace time in three African countries, Uganda, Ethiopia and Mozambique (Collier, 1995). Even six years after the military conflict in Rwanda areas which had experienced high intensity conflict had lower level of consumption compared to those who had experienced low intensity conflict (Serneels, 2012).

Exchange rate fluctuations and socio – political factors

Examining data on World War I Hall (2002) and Duarte et al. (2015) show that news had significant effect on exchange rates. Hall concludes that one of the factors which contribute to changes in exchange rates between the currencies of the countries of the Entente and Central Powers is information about casualties on the Western Front. For instance, exchange rate of Britain increased when more

British troops got killed or wounded compared to the Central powers since during the trench war the attacking side bears more casualties. Thus, traders expected that restoring gold convertibility and adopting deflation policies were more likely to take place in the winning country.

Laakkonen (2004) examines how news influence USD/EUR exchange rate volatility. As the general result which is consistent with earlier studies is that news lead to substantially higher volatility. Moreover, consistent news (only "bad", or only "good") cause significantly less exchange rate fluctuations than conflicting news ("bad" and "good" news contemporaneously).

Exchange rate fluctuations and socio – political factors: evidence from the developing countries

Odhuno (2009) tries to understand volatility of exchange rate in Uganda during Uganda Bah War (Ugandan civil war) by incorporating into time series specification non – economic factors a.k.a. socio – political variables such as HIV/AIDS related and war related news. The main result is that news related to regular government army attacks led to appreciation of Uganda shilling against U.S. dollar, on the other hand, news related to rebel attacks caused depreciation of the local currency.

Fielding and Shortland (2005) investigate extent to which political violence of radical Islamist groups in Egypt affect trust in the local currency and substitution between local and hard currencies, especially US dollar, in the light of reform steps which were evaluated as prosperous with respect to several reasonable criteria. Therefore, success of the reforms was offset by Islamist politically oriented violent actions which led to qualitatively different behavior of the economic agents. They also conclude that in order to increase effectiveness of the reforms political destabilizing forces should be considered and treated. The second main conclusion

is that increase in violence increased demand for hard currency (US Dollar) and decrease for local one, the other thing being equal.

Overall, most of the studies do confirm strong relationship between exchange rate and socio – political factors in developing countries, suggesting that if once violence increased and agents got informed then local currency depreciated which indicates link between financial markets and short – run fluctuation in the political factors.

Chapter 3

METHODOLOGY

In order to estimate effect of the violence on the exchange rate's fluctuations in Ukraine we will use two approaches. The first method is a classical regression analysis with ARIMA errors (another version of the ARIMAX models and a special case of the transfer function models) and possible ARCH effects (Dreger et al, 2015; Tsay, 2010; Fielding and Shortland, 2005; Odhuno, 2009). Secondly, Bayesian framework, Bayesian Model Averaging (BMA), is going to be applied (Zhukov, 2015; Ulfelder, 2012).

Regression analysis with ARIMA errors and ARCH effects

First of all, the logarithm of the black market volume – weighted average exchange rate will serve as a dependent variable throughout our analysis. The set of covariates includes excess demand at the black currency market, NBU's net interventions, violence related variables, the Brent oil prices, NBU's interest rate for overnight loans in UAH, and set of principal components related to NBU's restrictions. The one – parameter Box – Cox transformation with lambda set to the zero was applied to the whole set of the violence related variables, oil prices, and NBU's interest rate. Purpose of the Box – Cox transformation is to make variables more like normally distributed. All variables have daily frequency and ranges from 28 February, 2014 to 29 July, 2015 (construction of variables mentioned above is explained in more details in the next chapter).

Augmented Dickey – Fuller test with a trend was used for checking order of integration.

$$\Delta y_t = \alpha + \beta * t + \gamma * y_{t-1} + \delta_1 * \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p-1} + \varepsilon_t,$$

where α is a constant, β is the coefficient on a time trend component and p is the order of the autoregressive process.

The ADF test showed that majority of the variables are non – stationary (~80%) including dependent variable (see Table 7 for the sample results). In order to rule out a possibility of the spurious regression results the first difference was applied to the all non-stationary variables.

Analysis of the effect of war – related news on the black market exchange rate will be conducted using the next multistage procedure (Tsay, 2010):

1. Fitting the mean equation by classical regression model with ARIMA errors in order to remove all linear dependencies

2. Checking residuals of the mean equation for the white noise behavior and squared residuals for the ARCH effects

3. Residuals are modelled using GARCH model if ARCH effects are present

4. Checking the fitted volatility model

Further each of the stages mentioned above is described in more details.

Modelling the mean equation

The econometric model for the mean equation includes explanatory variables mentioned at the beginning of this section which are allowed to influence the dependent variable with a delay. Therefore, the following mean equation is going to be estimated:

$$\Delta \ln(BM)_t = \beta_0 + \sum_{k=1}^{n_1} \alpha_k Excess\ demand_{t-k} + \sum_{k=0}^{n_2} \beta_k \ln\left(\frac{Interventions\ Sell}{Interventions\ Buy}\right)_{t-k} +$$

$$+\sum_{k=0}^{n_3}\gamma_k\Delta\ln\left(NBU\ Overnigth\ Rate\right)_{t-k}+\sum_{j=1}^{J}\sum_{k=0}^{m_j}\delta_{kj}\Delta\ln\left(News_j\right)_{t-k}+$$

$$\sum_{k=0}^{n_4}\mu_k\Delta\ln(Oil\ prices)_{t-k}+\sum_{k=1}^{5}\theta_k PC_k\ +\eta_t \qquad (1)$$

$$\eta_t=\sum_{k=1}^{p}\varphi_k\eta_{t-k}-\sum_{k=1}^{q}\psi_k z_{t-k}+z_t$$

where BM – the black market rate, $News_j$ – j-th variable from the violence related set, PC_k – k-th principal component related to the NBU's restrictions, η_t~ARMA (p, q) process, J – the number of included violence – related variables

Checking the ARCH effect

Firstly, residuals ε_t from the mean equation model should be obtained and tested for the white noise behavior using ACF and PACF. In the case of non – white noise residuals, the mean equation should be re-defined and re-estimated.

Let's assume that dynamics of residuals from the mean equation exhibit white noise patterns. Then, squared residuals ${\varepsilon_t}^2$ would be calculated and checked for the conditional heteroscedasticity or the ARCH effects. For that purpose, LM test of Engle (1982) is going to be used:

$${\varepsilon_t}^2=\alpha_0+\alpha_1{\varepsilon_{t-1}}^2+\cdots+\ \alpha_m{\varepsilon_{t-m}}^2+e_t$$

where e_t - error term, m – positive integer.

The null hypothesis for this test is $H_0\colon\alpha_1=\cdots=\ \alpha_m=0$, with the alternative hypothesis $H_1\colon\alpha_i\neq 0$ for some i. If conditional heteroscedasticity is confirmed by the test, residuals ε_t will be modeled with the GARCH model.

The GARCH model

Since only lower order GARCH models proved their validity and power in most economic applications (Tsay, 2010), the GARCH(1, 1) will be applied to residuals ε_t. Moreover, exogenous variables are allowed to drive the volatility of the black market exchange rate (explained in the next chapter in more details).

$$\varepsilon_t = \sigma_t * e_t,$$

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \sum_{k=0}^{L} \lambda_k \Delta LBMR_{t-k}$$

where LBMR – the logarithmic black market premium, e_t – error term which follows a skew Student t distribution.

Finally, the validity of the volatility model will be checked by investigating the standardize residuals $\widehat{\varepsilon_t} = \frac{\varepsilon_t}{\sigma_t}$ and their squared values $\hat{\varepsilon}_t^2$ for the white noise behavior.

Bayesian framework

In the classical regression analysis, the best model M^* is used to make all inferences, but it is unclear what to do if you have closely competing model M^{**}. In other words, uncertainty regarding the "true" model should be accounted for in the results. Moreover, inferences based on the empirical study on conflict are very sensitive to the changes in the model specification (Hegre and Sambanis, 2006). Due to that reasons BMA is gaining popularity in researches on predicting conflicts (Montgomery et al., 2012; Ulfelder, 2012). BMA allows to aggregate inferences about coefficients across the full model space:

$$\Pr(\beta|D) = \sum_{l=1}^{2^n} \Pr(\beta|M_l, D) * \Pr(M_l|D)$$

$$\Pr(M_l|D) = \frac{\Pr(D|M_l)}{\sum_{k=1}^{2^n} \Pr(D|M_k) * \Pr(M_l)}$$

where n – number of predictors, D – data, M_l – l-th model from the model space, $\Pr(M_l|D)$ – posterior model probability, $\Pr(\beta|M_l, D)$ - posterior distribution of the β under l-th model, $\Pr(D|M_l)$ – likelihood of data, $\Pr(M_l)$ – prior probability that l-th model is the true model.

Based on the BMA, it is possible to compute posterior inclusion probability of a predictor:

$$\Pr(\beta \neq 0) = \sum_{k \in \{i:\beta \neq 0 \; in \; M_i\}} Pr(M_k|D)$$

And, posterior conditional mean and variance are provided by BMA as well:

$$\beta_k = E[\beta|D, M_k]$$

$$E[\beta|D] = \sum_{k \in \{i:\beta \neq 0 \; in \; M_i\}} \beta_k * Pr(M_k|D)$$

$$Var[\beta|D] = \sum_{k \in \{i:\beta \neq 0 \; in \; M_i\}} (Var[\beta|D, M_k] + \beta_k^2) Pr(M_k|D) - E[\beta|D]^2$$

BMA will be estimated on the same set of predictors as a classical regression model in the previous section. Additionally, lagged dependent variable is constructed since available realization of BMA does not allow ARMA structure of the error term.

Chapter 4

DATA DESCRIPTION

Data for the empirical analysis consist of several parts: the black market data, macroeconomic variables, metrics for war – related news, sanctions indices, and variables based on the NBU's restrictions. Further each of these parts is described in more details.

The black market data

The source for the black market data is a website finance.ua. Agents who would like to exchange foreign currency could publish their quotes on the website and indicate the currency, the exchange rate, the amount which has to be exchanged, the location, the type of the offer (sell or buy), and the telephone number. However, we do not have an information neither about the total number of completed offers nor about whether some particular bid led to the deal. Even though uncertainty regarding exact number of transactions is likely to inflate the true size of the parallel online market, the black market exchange rate could still serve as a proxy for the free market value of the currency (Huett et al., 2013).

In order to obtain the black market data, a web scrapping script had been executed which resulted in the total amount of 965, 760 offers which covers the period from 2014, Jan 1 till 2015, Dec 31. After leaving only such offers which have UAH on the one side and USD on the other, deleting duplicates (two offers are considered as duplicates if they have exactly the same values in corresponding fields within the day), and dropping outliers (quotes with unrealistic amounts like 111, 1234 or 56789, very small quotes (< 100$) and very big quotes (> 100,000$) were excluded; quotes which have exchange rate's values with absolute deviations from the median

exceeding 3 standard deviations were excluded as well) the total amount of offers shrank to 554, 670 entries.

Based on the cleaned black market data, volume – weighted average exchange rate for the USD – UAH pair was constructed. All offers, for the both buy and sell sides, from the online parallel market were aggregated at the daily basis.

$$Black\ Market\ Rate[t] = \frac{\sum_i ER[i][t]a[i][t]}{\sum_i a[i][t]},$$

where $ER[i][t]\ and\ a[i][t]$ are the exchange rate and a corresponding quantity are listed in the quote i of the day t. Dynamics of the black market rate will be discussed in the next section.

The parallel online currency market operates under free floating regime where exchange rates are determined by supply and demand as for any other commodity. In order to account for discrepancy between demand and supply in the black market, excess demand variable was constructed at the daily basis.

$$Excess\ demand[t] = \log\left(\frac{\sum_i a[i][t]*I[i_{type} = \text{Buy}]}{\sum_i a[i][t]*I[i_{type} = \text{Sell}]}\right),$$

where $a[i][t]$ is a quantity listed in the quote i of the day t, $I[\cdot]$ – indicator function.

Macroeconomic variables

Part related to the set of macroeconomic variables consist of daily time series on official market exchange rate (UAH and USD), NBU's interventions, Brent oil price and weighted average overnight rate for loans in UAH. Evolutions of the macroeconomic variables are depicted in Figure 3.

The second panel of Figure 3 shows dynamics of the exchange rates – both black market and official one. After achieving its peak during 25 - 26 February, 2015 (34 UAH/USD from the buy side and 38 UAH/USD – sell side for black market, 28 – 30 UAH/USD for official one) exchange rates decreased and stabilized in the range of 22 – 24 UAH/USD. Several structural breaks in the official exchange rate can be seen while the most significant one occurred during 4 – 6 February, 2015 when NBU devaluated Ukrainian hryvnia from 16, 7 UAH/USD to 23, 1 UAH/USD.

Saca (1997) and Onour (1996) pointed out that the black market premium is positively correlated with the illegal inflow of foreign currencies from the official market to the black market. Edwards (1989) and Kamin (1993) discovered that just before the devaluation of the official exchange rate the black market premium increases quickly and decreases right after that. Hence, a simple percentage and logarithmic black market premiums were constructed.

$$Simple\ Black\ Market\ Premium\ [t] = \frac{BR[t] - OR[t]}{OR[t]} * 100\%,$$

$$Logarithmic\ Black\ Market\ Premium[t] = \log(\frac{\mathrm{BR[t]}}{OR[t]}),$$

where $BR[t]$ and $OR[t]$ – black market exchange rate and official exchange rate. Figure 4 indicates that starting from the first half of January, 2015 till devaluation in the beginning of February, 2015 almost the highest simple black market premiums were observed. This suggests that during that period official market was unable to afford existing demand for foreign currencies and economic agents turned to the parallel online market. Moreover, the black market premium is likely to affect volatility of the black market exchange rate. Fig.3 and Fig.4 suggest that periods of relatively high premium are coincide with periods of relatively volatile

black market exchange rate. Consequently, the black market premium is allowed to drive the volatility of the black market exchange rate in the GARCH specification.

Weighted overnight rate for loans in UAH is depicted in the bottom panel of Figure 3.

News related data

Data on news related to war are taken from Zhukov (2015) which capture period from 28 Feb, 2014 to 31 July, 2015. There are daily time series data aggregated from different sources (Ukrainian, Russian, rebel and international) where majority of the variables indicate number of municipalities with a particular violent event (the total number of municipalities with violent events in a given day is depicted in the Fig.1). Besides that, there are variables for proportion of municipalities under rebel control and average distance from the front line. Table 1 shows descriptive statistics for the sample of four variables.

Table 1. Descriptive statistics for violence related variables

	min	median	mean	max	std.dev
# of m-es with any violent event	0.0	18.0	21.9	93.0	17.0
# of m-es with casualties	0.0	4.0	5.7	40.0	6.3
% of m-es under rebel control	0.3	0.4	0.4	0.4	0.0
Distance to the front	33.1	40.5	41.2	138.9	10.8

While distributions of total number of municipalities with violence and casualties have long and fat right tails, proportion of municipalities under rebel control and average distance from the front line are highly concentrated around their mean (median) values (Figure 5).

Sanctions indices

Starting from the annexation of the Crimea, Western countries imposed sanctions against individuals, firms, and industries in Russia in order to speed the signing of the peace agreement (Dreger et al., 2015). Due to that reasons, sanctions are likely to affect evolution of the conflict and, in turn, dynamics of the exchange rate in Ukraine.

Data on sanctions imposed against Russia from Western countries and vice versa are obtained from Dreger et al. (2015). Dynamics of sanctions indices are depicted in Figure 6. Please refer to Dreger et al. (2015) for detailed information regarding methodology.

Restrictions based variables

Official foreign exchange market was a subject to the wide range of restrictions imposed by the NBU over 2014 – 2015 years. Government restrictions on sale and official price ceilings create excess demand for a commodity which crucially influence development of the black market (Caporale and Cerrato, 2005; Banuri, 1989). In order to account for the effect of the NBU's decisions on the black market, variables related to the FX restrictions were built using the next two stage methodology:

1. Data regarding restrictions was retrieved manually from the NBU's decrees and reports related to the monetary and financial operations. All reports and decrees issued in the period of 2014 – 2015 were checked and processed (see Table 6 for almost complete data from that stage).

2. Three categorical variables and set of dummy variables were constructed based on a processed information:

    a. Percentage of FX earnings which should be sold on the IBFXM

b. Maximum allowed amount of UAH cash to exchange

c. Maximum allowed amount of UAH cash to withdraw through ATM, cashier's offices, etc.

d. Set of dummy variables which indicates changes in the procedure of buying FX by banks on client's instruction

Figure 7 shows dynamics of variables mentioned above. In the top right panel of Figure 7 combined set of dummy variables is depicted and its peak on 25 February, 2015 coincides with the highest exchange rate observed both in the official and black markets.

However, after converting each categorical variable to the set of dummy variables columns of the resulting comprehensive matrix turned out to be linearly dependent. The cause of the perfect multicollinearity between columns of the resulted matrix is an adoption of several FX restrictions under the same decree (date). In order to resolve problem of the perfect multicollinearity the PCA was applied.

The main idea of the PCA is to build m new variables or principal components and based on which n initial variables could be linearly restored with a minimal information losses (where $m < n$). An information losses imply the loss of the total variation. The number of principal components m is called effective dimensionality. The threshold ε for the losses $E[m]$ is set at the level of 0.05 (or 5%). More formally:

$$E[m] = \frac{\sum_{m+1}^{n} \lambda_k}{\sum_{1}^{n} \lambda_k} \leq 0.05$$

where λ_i is i – th eigenvalue of the matrix $F^T F$ (F – initial matrix of variables).

Table 2 suggests that under our threshold ε the effective dimensionality of the initial set of variables is 5.

Table 2. Principal component analysis

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Standard deviation	1.90	1.49	1.01	0.97	0.91	0.52	0.31	0.15	0.00
Proportion of Variance	0.40	0.25	0.11	0.10	0.09	0.03	0.01	0.00	0.00
Cumulative Proportion	0.40	0.65	0.76	0.86	0.96	0.99	1.00	1.00	1.00

So, we ended up with five principal components which do not suffer from multicollinearity while preserving more than 95% of the information about initial set of variables.

Chapter 5

EMPIRICAL RESULTS

Estimation results consist of two parts: first part – classical regression analysis with ARMA errors and GARCH effects, second part – Bayesian model averaging.

Classical regression analysis

First of all, we started with estimation of the mean equation (1). All explanatory variables are allowed to have impact on the black market exchange rate with a lag up to seven days (one week). The final model was chosen based on the Akaike information criterion. Due to that, residuals of the mean equation should satisfy white noise behavior.

Table 3 shows results from the final specification of the mean equation.

Table 3. The determinants of the black market exchange rate

$\Delta ln(BM\ Rate)_t$	Estimate	t value	Pr(>|t|)
$\Delta ln(\#\ of\ municipalities\ with\ any\ violent\ event)_{t-3}$	0.001	1.58	0.11
$\Delta ln(\#\ of\ municipalities\ with\ WIA\ Civillian)_{t-2}$	0.001	2.00	0.05
$ln(\frac{Interventions\ Sell}{Interventions\ Buy})_{t-2}$	-0.000	-1.41	0.16
$\Delta ln(NBU\ Overnigth\ Rate)_{t-2}$	0.041	2.33	0.02
$Excess\ Demand_{t-1}$	0.015	14.61	0.00
PC#1	0.001	1.75	0.08
PC#5	0.004	3.02	0.00
AR_{t-1}	0.936	14.94	0.00
MA_{t-1}	-0.593	-7.49	0.00
MA_{t-2}	-0.262	-4.94	0.00
$Intercept$	-0.004	-3.23	0.00

ACF and PACF of residuals from the mean equation suggest white noise behavior (Fig.8).

Most of coefficients are significant at the 5% significance level. Moreover, all coefficients have expected sign. Particularly, increase in both violent related variables lead to the depreciation of the Ukrainian currency.

A twofold increase in the ratio of numbers of municipalities with wounded civilians at time t – 2 and time t – 3 leads to the 0.1% increase in the ratio of the black market exchange rates at time t and t – 1. Similar numerical results are obtained for the effect of the number of municipalities with any violent event on the exchange rate.

An increase in the amount of the USD sold by the NBU through interventions into IBFXM causes appreciation of the Ukrainian hryvnia at the black market. However, economic impact is negligible. A rise in the NBU's rate for the overnight loans has the biggest economic impact among covariates on the black market exchange rate and leads to the depreciation of the hryvnia. The first and fifth principal components of the NBU's FX restrictions trigger appreciation of the hryvna at the black market as well. Altogether, it is a strong evidence that changes in the NBU's policies lead to the higher depreciation of the hryvna than violent related factors.

Coefficients near the excess demand and autoregressive term indicate that dynamics of the black market at the time t is highly dependent on its past values at time t – 1 and t – 2.

LM test of Engle (Fig.9) strongly suggests presence of ARCH effects in residuals from the mean equation. Results from the volatility model for residuals are shown in Table 4.

Table 4. The volatility model

σ_t^2	Estimate	t value	Pr(>|t|)
Intercept (Mean equation)	-0.001	-1.66	0.10
Intercept (Variance equation)	0.000	2.79	0.01
ϵ_{t-1}^2	0.507	2.90	0.00
σ_{t-1}^2	0.444	4.33	0.00
$LBM\ Premium_t$	0.001	1.80	0.07

All estimates are significant at the 10% level while ARCH and GARCH at the level less than one per cent. There is an evidence that logarithmic black market premium drives the volatility of the black market exchange rate which is not surprising.

Standardize residuals and their squared values exhibit white noise behavior (Fig.10 and Fig.11) which indicate that our GARCH(1,1) specification for residuals from the mean equation is adequate.

Bayesian model averaging

Results from the Bayesian model averaging are present in the Table 5 (covariates are sorted according to the posterior inclusion probabilities). It suggests that four variables have inclusion probabilities greater or equal than 0.95 and they influence the black market exchange rate persistently throughout the model space.

Table 5. PIPs, conditional means and standard deviations (random priors)

$\Delta ln(BM\ Rate)_t$	P(b <> 0)	E(b|b <> 0)	Std(b|b <> 0)
$Excess\ Demand_{t-1}$	1.00	0.013	0.001
$\Delta ln(BM\ Rate)_{t-1}$	1.00	0.242	0.037
PC#1	0.99	0.001	0.000
PC#5	0.95	0.002	0.001
$ln(\frac{Interventions\ Sell}{Interventions\ Buy})_{t-2}$	0.53	-0.001	0.000
$\Delta ln(\#\ of\ municipalities\ with\ WIA\ Civillian)_{t-2}$	0.51	0.002	0.001
$\Delta ln(NBU\ Overnigth\ Rate)_{t-2}$	0.38	0.035	0.019
$\Delta ln(\#\ of\ municipalities\ with\ any\ violent\ event)_{t-3}$	0.21	0.001	0.001

Conditional posterior means of coefficients are very similar to those obtained using classical regression analysis which suggests consistency of the results. Only predictors related to the black market itself have posterior inclusion probabilities of 1 which suggests presence of inefficiencies at the market. Past values of the excess demand at the black market and recent changes in the exchange rate have the highest and persistent economic impact (except NBU's overnight rate, but its PIP is 2,5 times lower) on the future exchange rate. At the same time, both excess demand and the black market exchange rate are observable and could be quickly collected using appropriate technology. Consequently, a fast accessibility of the recent black market data and its significant predictive power of the future exchange rate create favorable conditions for arbitrageurs.

NBU's FX restrictions and interventions consistently outperformed violence related factors in terms of an inclusion probability. The number of municipalities with wounded civilians turned out to be insignificant in the 49% of the all models from the model space. There is also a little evidence that number of municipalities with any violent event affects the black market exchange rate with an inclusion probability of 0.21.

The coefficients' posterior standard deviations in Table 5 suggest the next: the past dynamics of the black market and NBU's restrictions surely positively affect the current evolution of the exchange rate, while NBU's interventions are likely to have negative impact.

Figure 13 shows that posterior inclusion probabilities of the violence-related variables are highly sensitive to the changes in the underlying priors. For example, PIP of the number of the municipalities with wounded civilians ranges from 0.34 to 0.6. At the same time, PIPs of the black market related factors and the NBU's restrictions experience a little (if any) changes under different priors. Thus, almost

stable PIPs suggest robustness of the evidence and confirms our previous statement regarding possibilities of the arbitrage.

Chapter 6

CONCLUSIONS

This paper investigates the effect of the news related to the military conflict in Eastern Ukraine on the black market exchange rate for the period of February 2014 – July 2015. The classical regression analysis and Bayesian framework were applied.

Both approaches showed very similar and positive estimates of an economic impact of the war – related news on the black market exchange rate's evolution. It means that escalation of the conflict in the Donbass leads to the depreciation of the Ukrainian hryvnia at the black market with a delay of 2 – 4 days. Regression analysis indicates that the number of municipalities with wounded civilians affects significantly exchange rate's dynamics, while BMA shows that its PIP is 0.52 under random priors. In other words, 52% of the all models from the model space (2^8 = 256 models) includes the number of municipalities with wounded civilians as a significant predictor. Goodman (2008) pointed out that p – values tend to overestimate significance of the outcome compared to the PIPs. The similar pattern we could observe in our results.

Besides violence – related factors, changes in the NBU's policies crucially affect the black market exchange rate. The NBU's FX restrictions are among the most influential predictors which PIPs are higher than 0.95. Majority of the restrictions imposed by the NBU on the official market were aimed to lessen demand for the foreign currencies. As a result, extra demand occurred in the black market and drove the exchange rate up. Moreover, PIPs of the FX restrictions are highly robust to the changes in the underlying priors. Meanwhile, the NBU's interventions and overnight rate are likely to have a lower impact on the black market exchange rate

compared to the FX restrictions with PIPs of 0.61 and 0.43 correspondingly. Additionally, it was shown that their PIPs are sensitive to the changes in priors.

Finally, we found that the black market suffers from inefficiencies which could create comfortable conditions for arbitrageurs. On the one hand, past dynamics of the black market is the strongest predictor of the future movements and volatility, moreover, it is highly persistent across different priors and models. On the other hand, the actual data from the black market could be quickly accessed and processed using technology. As a result, decisions based on the data insights might lead to arbitrage opportunities.

Further extensions of this thesis could additionally link the deposit accounts and remittances of migrants to the black market exchange rate. Besides that, modern models and techniques such as neural networks and ensemble decision trees methods might be applied.

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APPENDIX A: Military conflict, currency black market and macroeconomic variables

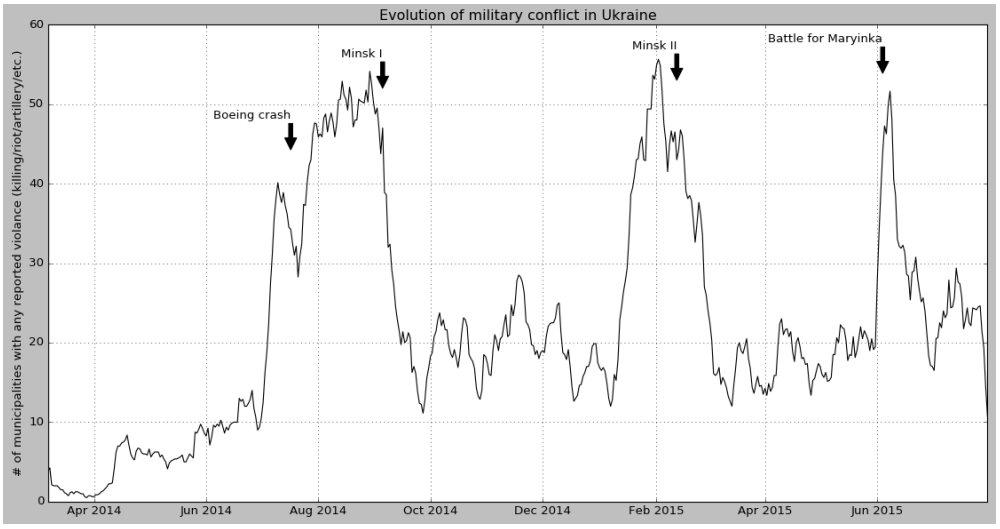

Figure 1 – Evolution of the military conflict in the Donbass region

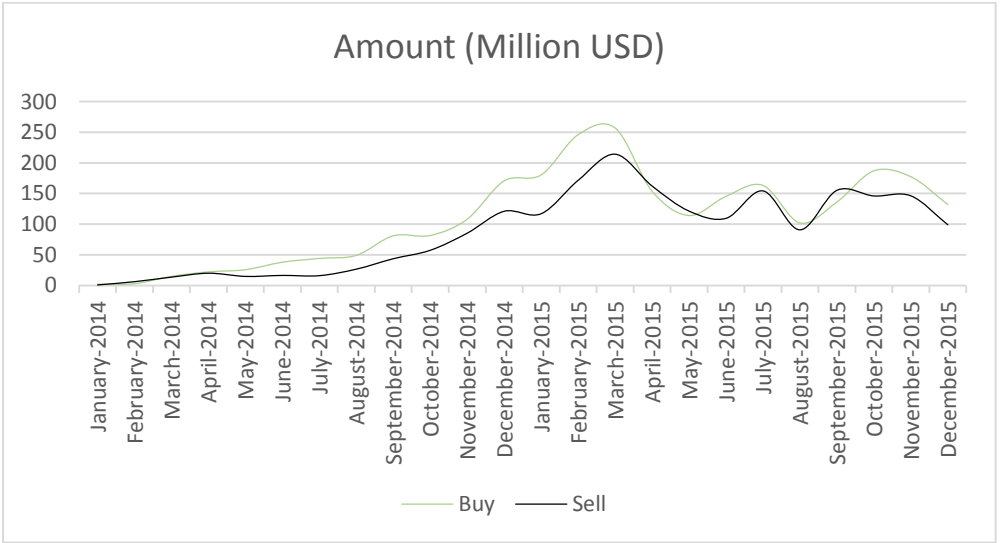

Figure 2 – Volume of the currency black market

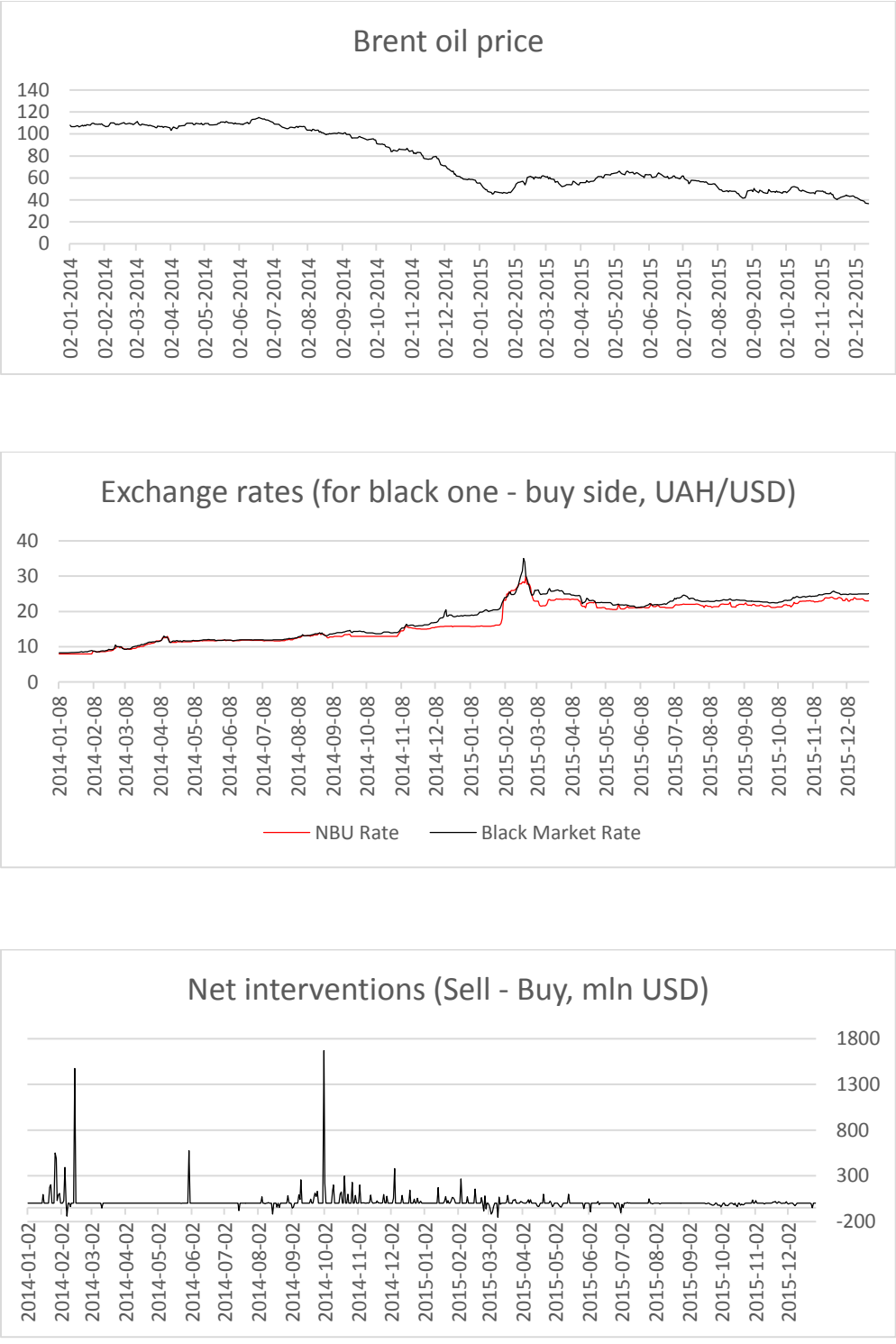

Figure 3 – Evolutions of macroeconomic variables

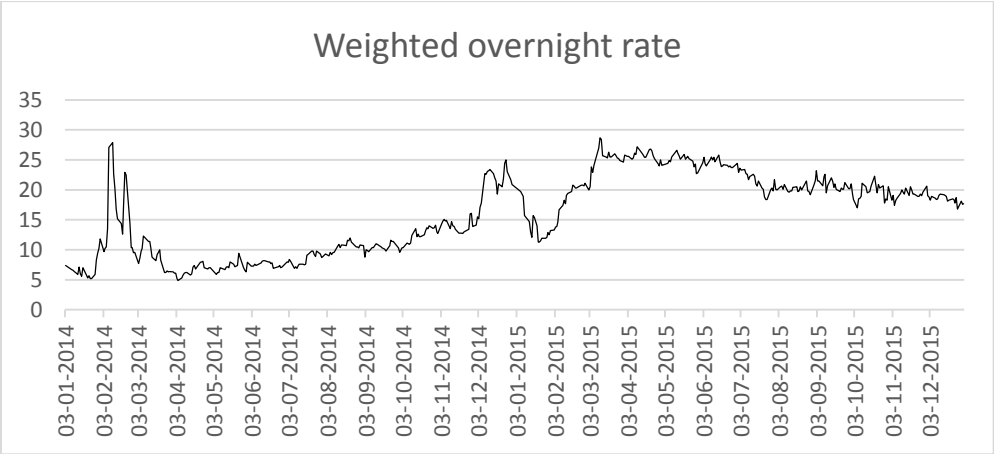

Figure 3 – Evolutions of macroeconomic variables

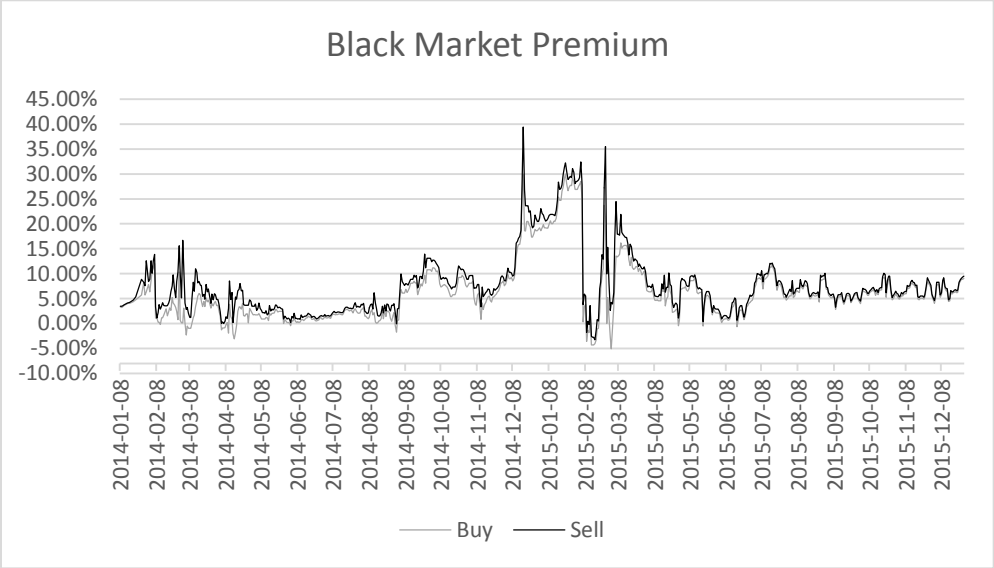

Figure 4 – Black market premium

APPENDIX B: Violence related data and sanctions indices

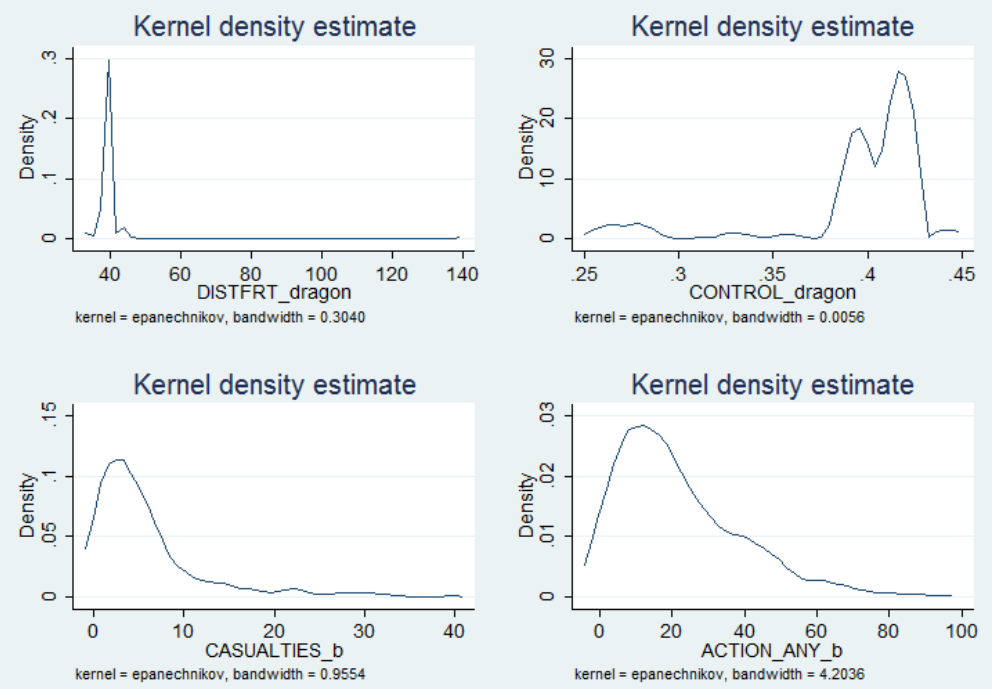

Figure 5 – Distribution of violence related variables

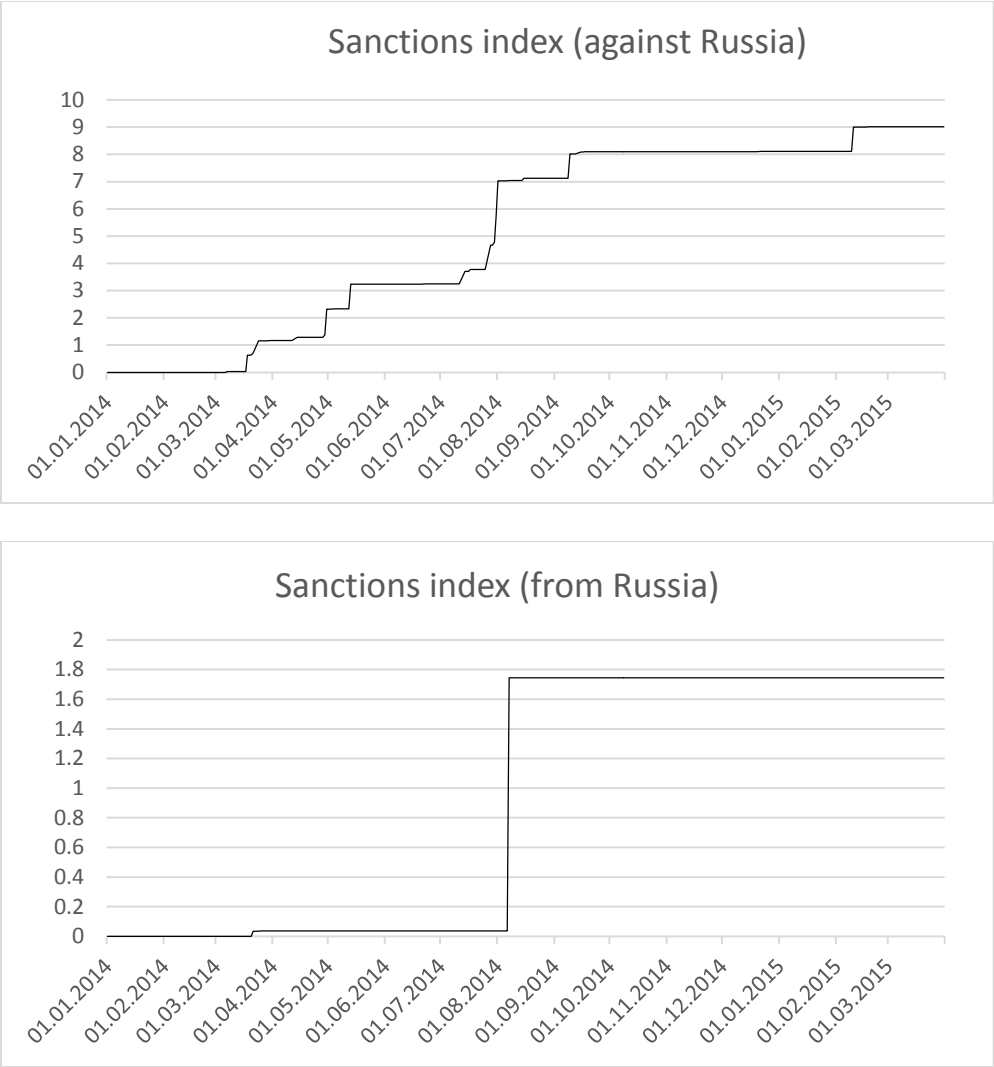

Figure 6 – Sanctions indices

APPENDIX C: Restrictions imposed by the NBU on the FX operations

Table 6. The NBU's FX restrictions in a processed form

From	Desription	Relief
07 - Feb - 2014	temporary restrictions on the purchase of foreign currency on the interbank currency market of Ukraine on individual transactions	
	Temporary limits on fx purchases under current non-trading operations aimed at making transfers abroad (up to UAH 50 thousand)	
28 - Feb - 2014	the restriction on withdrawal of FX cash or investment metals from client`s accounts through cashier's offices and ATMs up to an equivalent of UAH 15,000 per day per customer	4 - Sep - 2015: amount increased to an equivalent of UAH 20,000 per day per customer
28 - Mar - 2014	Cash fx purchases from individuals for the amount up to UAH 150, 000 are allowed without id	
	sale of fx to one person in one operation day in an amount not exceeding the equivalent of 15, 000 UAH within one banking institution with ID	
	FX cash transfers on behalf of individuals can be made abroad as current non-trade transactions without documentary evidence for the amount not exceeding an equivalent of UAH 15,000 within a month, more than 15, 000 UAH with documents, but no more than 150, 000 UAH (with exeptions)	
01 - June - 2014	the restriction on withdrawal of UAH cash from clients' accounts through cashier's officies and ATMs up to 150 000 UAH per day per customer	04 - June - 2015: up to UAH 300,000
21 - Aug - 2014	Requirement to sell fx earnings in the IBFXM has been raised from 50% to 100%	
02 - Sep - 2014	client`s funds in UAH should be deposited upfront to a separate a/c to purchase FX and could be transfered not earlier than on 3th day	25 - Feb - 2015: on 4th day

Table 6. Continued

From	Desription	Relief
23-Sep-2014	max cash fx sale per capita per day **3000** UAH	
	requirement to sell 100% of fx earnings on IBFXM reduced to 75%	
3 - Dec - 2014	the prohibition of the repatriation of proceeds or corporate rights and dividends to foreign investors	
24 - Feb - 2015	the NBU`s approval for advance payments for imported goods/services exceeding USD 50 000	
	the letter of credit for import contracts exceeding USD 500 000 confirmed by investment grade bank	
	the ban is imposed on purchase of FX at the instruction of a client if loan in UAH is used for this purpose	26 - Feb - 2015 (announced on 25 - Feb - 2015): relax prohibition of FX purchase
25 - Feb - 2015 (announced on 24 - Feb - 2015)	**the prohibition of purchase FX at the instruction of a clients up to 27 - Feb (inclusive)**	
4 - Mar - 2015	the restriction on the sale of banking metals exceeding 3,216 troy ounce of gold for their own banks` benefit within a 1 week per client	
	the prohibition to extend loans in UAH to the customers, if the property rights for the FX held in the bank's accounts are pledged as collateral against such loans	04 - Jun - 2015: EUR 50, 000
	the value of the contract that is exceeding EUR 25,000 is a subject to a price examination for transactions performed by residents to pay for works, services, intellectual property rights	04 - Jun - 2015: USD 25, 000
	the restriction to purchase FX at the instruction of a resident client with FX holdings on current and deposit accounts with banks, if the total FX amount held in client's accounts exceeds USD 10,000	

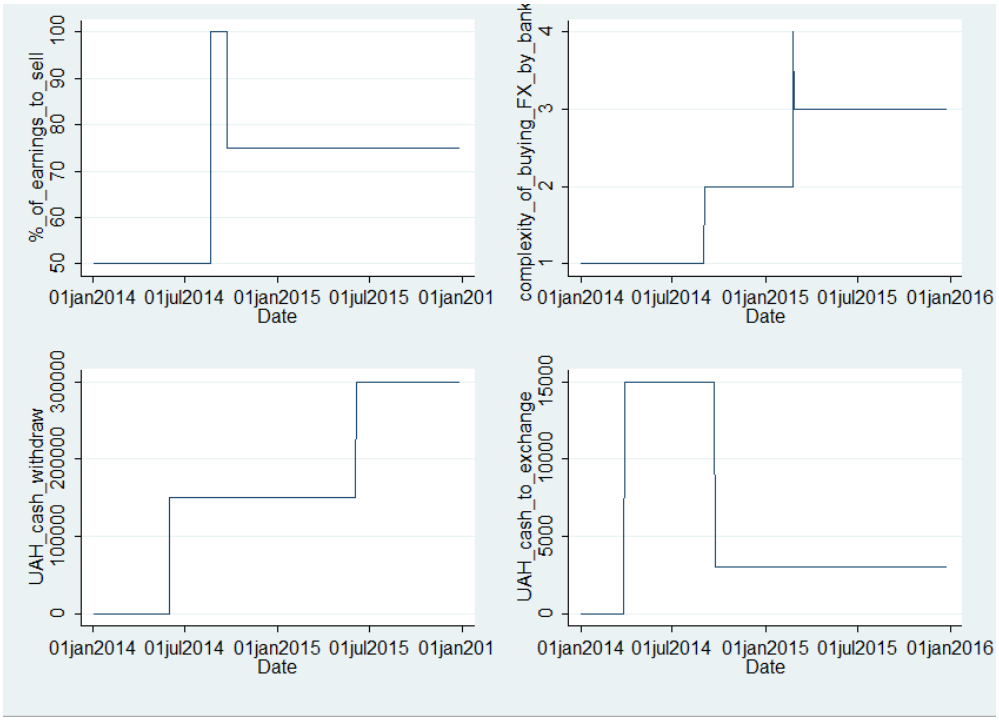

Figure 7 – Variables related to imposed restrictions

APPENDIX D: Model estimation results

Table 7. Sample results from the ADF test

	Variable	Type	p-value
1	INITIATOR_G_b	Not	0.4
2	INITIATOR_R_b	Not	0.4
3	INITIATOR_C_b	Stationary	0.0
4	INITIATOR_O_b	Stationary	0.0
5	INITIATOR_U_b	Not	0.4

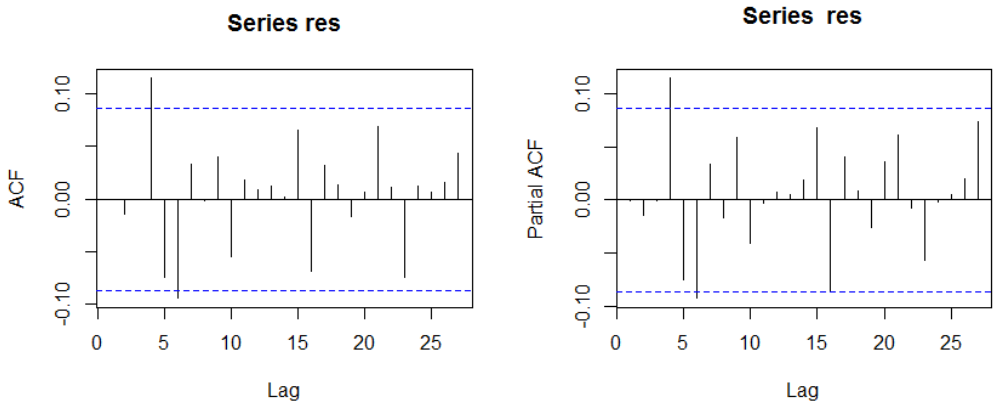

Figure 8 – ACF and PACF of residuals from the mean equation

```
        ARCH LM-test; Null hypothesis: no ARCH effects

data:  sq_res
Chi-squared = 21.491, df = 10, p-value = 0.01792
```

Figure 9 – LM test of Engle

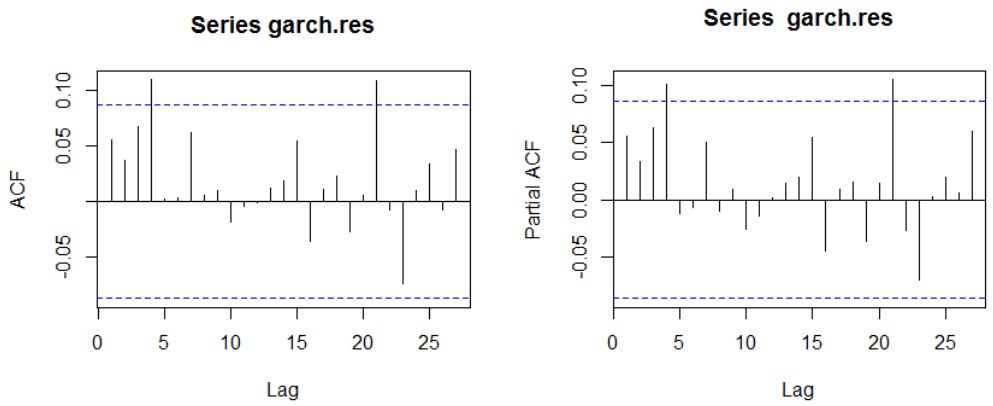

Figure 10 – Standardize residuals from the volatility model

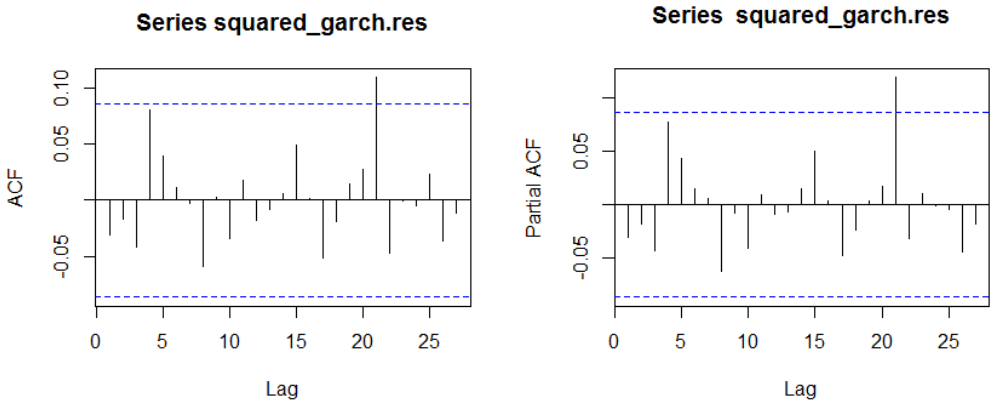

Figure 11 – Squared standardize residuals from the volatility model

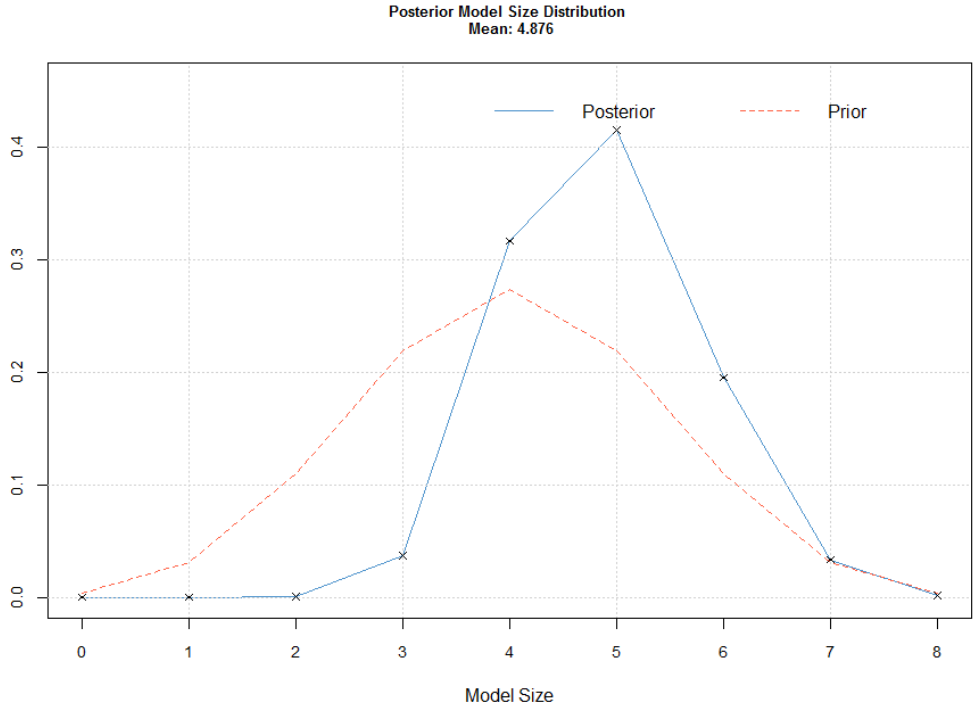

Figure 12 – Posterior model size with uniform priors

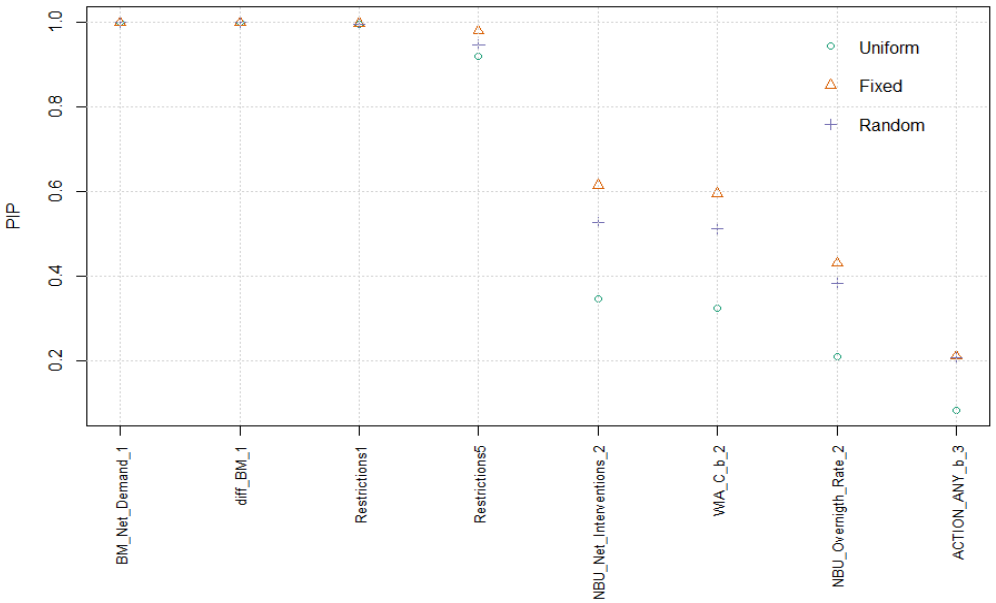

Figure 13 – Comparison of PIPs with different priors