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Piotr Mielus*
ORCID: 0000-0003-0194-5172
pmielus@sgh.waw.pl

Reaction of the financial market: a comparison of the war in Ukraine and the COVID-19 pandemic in Europe

Abstract

The article explains a reaction of various segments of the financial market on the Russian aggression against Ukraine. Three groups of market segments are described: countries engaged directly in the war, selected European countries outside the Eurozone and the Eurozone itself. The focus is taken on three kinds of instruments representing currency risk, credit risk and liquidity risk. The current market reaction is compared with the one observed after the outbreak of the COVID-19 pandemic. If we assume scepticism about the intelligence warnings, the Russian attack that started on February 24, 2022 can be perceived as a black swan event due to the huge scale of the market reaction. The financial market experienced a volatility rise and an increased correlation between returns recorded on the selected instruments. The aim of this study is to analyse an influence of the military actions on prices recorded on the financial market in a light of a black swan theory.

Key words: financial market, black swan, emerging markets, market volatility

JEL: G12, G15

Reakcja rynku finansowego na wybuch wojny rosyjsko-ukraińskiej w porównaniu do reakcji na wybuch pandemii COVID-19 w Europie

Streszczenie

Artykuł wyjaśnia reakcję poszczególnych segmentów rynku finansowego w Europie na agresję rosyjską na Ukrainę. Omówiono trzy grupy rynków, tj. krajów dotkniętych wojną, wybranych krajów CEE pozostających poza strefą euro i strefy euro, a także trzy grupy instrumentów reprezentujących ryzyko walutowe, kredytowe i płynności. Porównano obecną reakcję rynku z reakcją spowodowaną wybuchem pandemii COVID-19. Oba zdarzenia można

* Piotr Mielus – Department of Quantitative Economics, Warsaw School of Economics.

klasyfikować jako materializację zjawiska czarnego łabędzia. W przypadku wybuchu wojny takie podejście jest możliwe przyjmując sceptycyzm wobec ostrzeżeń ekspertów czy informacji wywiadów niektórych państw oraz skalę zmian cen instrumentów na rynku finansowym po wystąpieniu zdarzenia. Jest to szczególnie widoczne w nagłym wzroście zmienności oraz zwiększonej korelacji pomiędzy parametrami poszczególnych segmentów rynku finansowego.

Słowa kluczowe: rynek finansowy, czarny łabędź, rynki wschodzące, zmienność rynkowa

Introduction

A black swan is a phenomenon, process or an event that, on a one hand, is unexpected due to a low probability of its occurrence and, on the other hand, leads to severe consequences (Taleb 2007). Under certain assumptions, the COVID-19 appearance in China was such an event, which caused announcement, by WHO in January 2020, of the international health threat and brought a lockdown of the numerous countries around the world (Antipova 2020). The pandemic impacted a social and economic life in a few waves, but only the first wave was a shock that had an influence on prices on the financial market. Before the end of the COVID-19 pandemic could be announced, another meaningful event was triggered. On February 24, 2022 the Russian troops crossed the Ukrainian border. The war in Ukraine has a constant and significant effect on geopolitics, economy and risk perception not only in Europe.

On a one hand, this event was forecasted by the US intelligence on the basis of a massive troops concentration on the border of Ukraine. On the other hand, after the Russian annexation of Crimea in March 2014 one has witnessed such concentrations several times on the pretext of military manoeuvres. The military escalation has been forecasted unavailingly a few times. Therefore, the outbreak of a full-scale war was a surprise for a majority of the observers. The shock related to the war was accompanied by an unprecedented strong resistance of the Ukrainian army and a broad package of sanctions imposed on Russia soon after the attack. These sudden series of events and a dramatic increase of uncertainty can be described as a black swan phenomenon.

Every black swan event causes rise of a risk aversion due to sharp deterioration of a market sentiment. A scale of the market change depends on a scope of the surprise and a strength of its impact. The war between Russia and Ukraine has huge influence on the financial market. It comes from the following reasons. Firstly, a war in a NATO and EU neighbouring country increases geopolitical risk. Secondly, a crucial role of Russia on energy commodities market and Ukraine on soft commodities market results in an augmented inflationary pressure and a risk of recession. It means an appearance of the stagflation risk, which could be observed in the past during the oil shocks after Jom Kippur war in 1973. Such pessimism is related to the state

of European economy when the war broke out. The two-year pandemic created economic disequilibria followed by a fiscal and monetary stimulation. Therefore, the EU financial market was sensitive to adverse shocks. It exacerbated the increase of a global risk aversion (Liadze et al 2022). The aversion was clearly visible in the both countries affected in the war (Russia and Ukraine) and neighbouring non-euro countries (Poland, Hungary, Czechia).

The article, on the basis of price, volatility and correlation analysis proves that the outbreak of the war in Ukraine can be treated, likewise COVID-19, as a black swan.

1. Financial markets and the change of gold and oil prices

We analyse time series covering the period 1.01.2020–15.03.2022 in order to assess a scope of reaction of the financial market in relation to the black swan event. Data contain full period of the COVID-19 pandemic and a few first weeks of the war in Ukraine. The list of currencies is as follows: euro (EUR), Polish zloty (PLN), Hungarian forint (HUF), Czech crown (CZK), Russian rouble (RUB) and Ukrainian hryvna (UAH). All these markets (except UAH) has floating currency regime and liberal currency law. A volatility of foreign exchange rate and other market parameters are shaped by forces of demand and supply.

We collected prices of financial instruments representing various kinds of risk. Risk is an object of trade and financial instruments are legal products with embedded financial risk. Table 1 presents availability of these instruments for the selected currencies.

Table 1. Instruments analysed in the research

Price	Risk	Instruments	Currencies
Spot rate	Linear currency risk	FX Spot	EUR/USD, EUR/PLN, EUR/HUF, EUR/CZK, USD/RUB, USD/UAH
ATM volatility for vanilla FX option	Non-linear currency risk (variance)	FX Option (3M ATM)	EUR/USD, EUR/PLN, EUR/HUF, EUR/CZK
Risk Reversal	Non-linear currency risk (skewness)	FX Option (3M 25-delta OTM)	EUR/USD, EUR/PLN, EUR/HUF, EUR/CZK
Butterfly	Non-linear currency risk (kurtosis)	FX Option (3M 25-delta OTM)	EUR/USD, EUR/PLN, EUR/HUF, EUR/CZK
Currency Basis Spread	Cross-border liquidity	3M implied FX Swap minus 3M IBOR & 5Y CCBS	EUR/USD, EUR/PLN, EUR/HUF, EUR/CZK

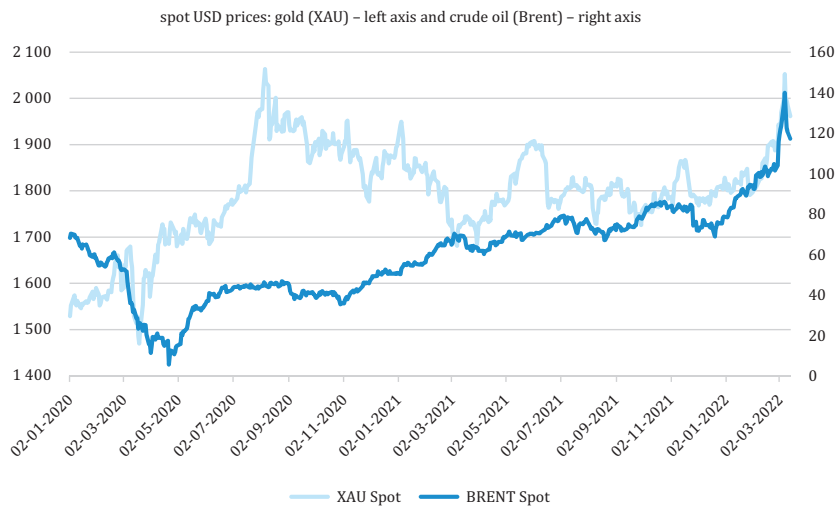
Table 1 – continued

Price	Risk	Instruments	Currencies
Asset Swap Spread	Credit and liquidity risk of treasury bonds	5Y T-Bond minus 5Y IRS	EUR, PLN, HUF, CZK
Credit Default Swap	Risk of issuer's default	5Y CDS	Issuers: Germany, Poland, Hungary, Czechia, Russia, Ukraine

Source: Own elaboration.

Before we look at the selected local markets, we examine the prices of two crucial commodities important for economic stability and sensitive to the current financial sentiment: gold and crude oil.

Chart 1. Gold and oil prices between 2020–2022



Source: Refinitiv.

Despite the similar "black swan" origin of the COVID-19 and the war in Ukraine, the reaction of gold and oil prices was different. The difference comes from various reasons of the outbreak of the crisis and its macroeconomic consequences.

The pandemic caused a sudden limitation of demand, especially on energy commodities, due to legal constraints related to mobility and economic activity. It brought sharp drop of oil and gold prices. The latter was cheaper as was perceived as overbought and liquid enough to be sold. Investors needed cash to cover losses and collateral calls on other markets (Goldhub 2020). A return to the appreciation trend on both markets was possible thanks to fiscal stimulation and gradual removal of the pandemic constraints. Gold appreciated almost immediately, but oil prices needed a few months to rebound. Due to the recurrent waves of the pandemic, the demand on oil was fragile and supported mainly by financial shields. In parallel the risk aversion fostered gold as a classic safe haven asset.

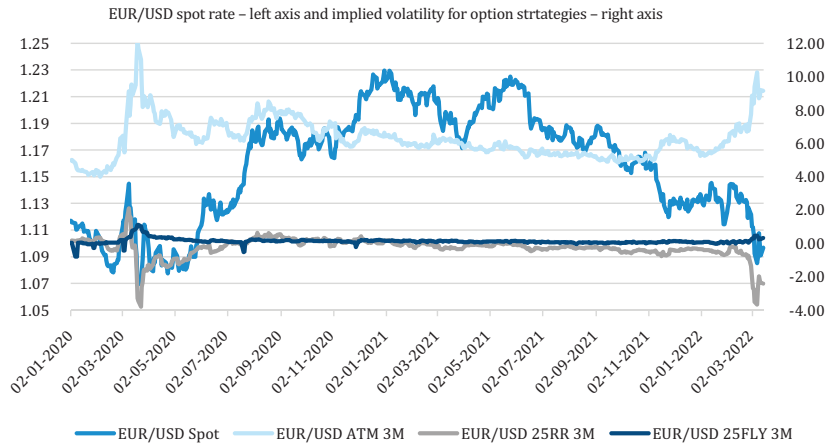
The Russian invasion on Ukraine gave rise to both assets. The correlation between oil and gold returns reached unprecedented 70%. Gold appreciated as a typical store of value during the war. Oil, in turn, was affected by import limitations from Russia and earlier appreciation of gas. Simultaneously, the market witnessed a 35% drop in emission trading prices (ETS carbon dioxide). It was surprising as the ETS price used to be strongly correlated with oil and gas prices. Likewise in the described reaction of gold investors two years earlier, the drop of ETS prices was connected with profit taking activities (after the prices had tripled in 6 months only) and loss covering or collateral calls on the oil and gas markets. Moreover one expected decrease in demand on emission rights from corporates affected by the war and high energy prices (Abettan et al. 2022).

The following section explains financial market reaction in various groups of countries regarding currency, credit and liquidity risk, taking into account the described economic environment.

2. Reaction of the euro financial market

Eurozone was perceived as stable during the COVID-19 pandemic and the outbreak of the war did not have negative impact on investors. The proof for that are CDS prices for Germany that rose in March 2022 from 6 to 10 bp only, what is much lower than during the first wave of the pandemic (18bp in March 2020). Nevertheless, the market noticed the higher risk of Eurozone in comparison to the US market due to the higher dependence on Russian energy commodities. It impacted EUR/USD that dropped by 4% following option prices change: ATM volatility rose from 6% to 10%, risk reversal dropped from -0.75% by almost 300 bp and butterfly rose from zero to 0.40%. Spot rate and its volatilities are presented on chart 2.

Chart 2. EUR/USD currency market between 2020–2022



Source: Refinitiv.

One observes a strong correlation between the analysed variables (table 2).

Table 2. EUR/USD Pearson correlations during the war in Ukraine

	dSpot	dATM	dRR	dFLY
dSpot	100%			
dATM	-77%	100%		
dRR	67%	-76%	100%	
dFLY	-59%	72%	-82%	100%

Source: Own calculations based on Refinitiv data.

Weakening of euro against dollar meant a rise of expected volatility and kurtosis and deepening of the negative sign of skewness, what suggested a risk of a further sudden euro depreciation. It is worth adding that an increased co-dependence between a price and its volatility is observed mainly in periods of turbulences on the market. An analysis of EUR/USD times series shows that in calm periods there is no correlation between a change of the spot rate and the higher moments of the distribution and the latter is close to normal. The outbreak of the war

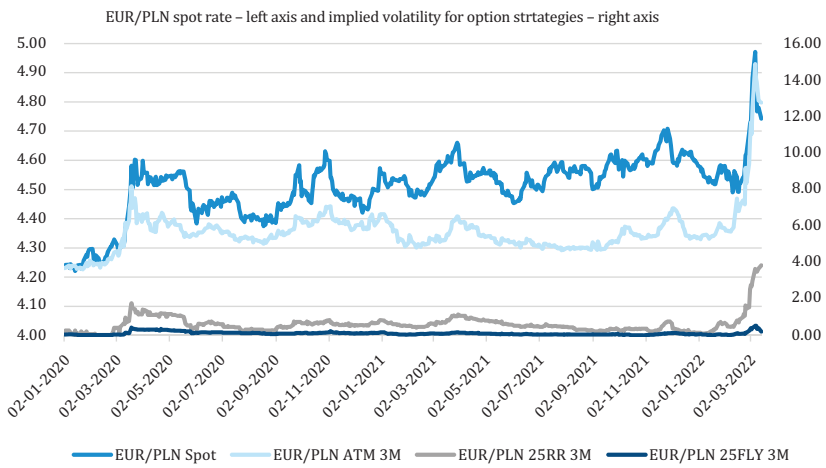
changes the market perception due to an effect of surprise and unknown long-term repercussions of the conflict.

Sudden and strong reaction of the option market and the correlation rise is an evidence of the existence of the black swan phenomenon in relation to February 2022 events.

3. Reaction on the CEE financial market

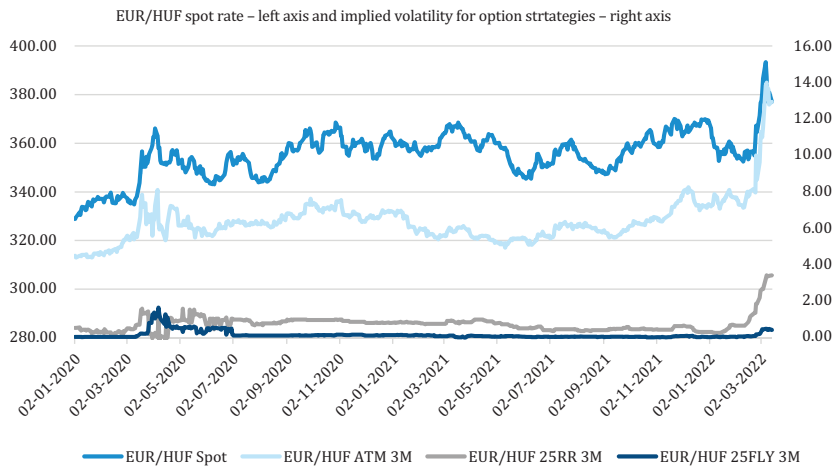
Poland, Hungary and Czechia are treated as correlated EU markets with own currencies, liquid emerging economies and liberal currency law. After the Russian invasion Poland and Hungary became frontal countries due to the common border with Ukraine. It had negative implication of risk perception on these markets what is visible on the following charts.

Chart 3. EUR/PLN currency market between 2020–2022



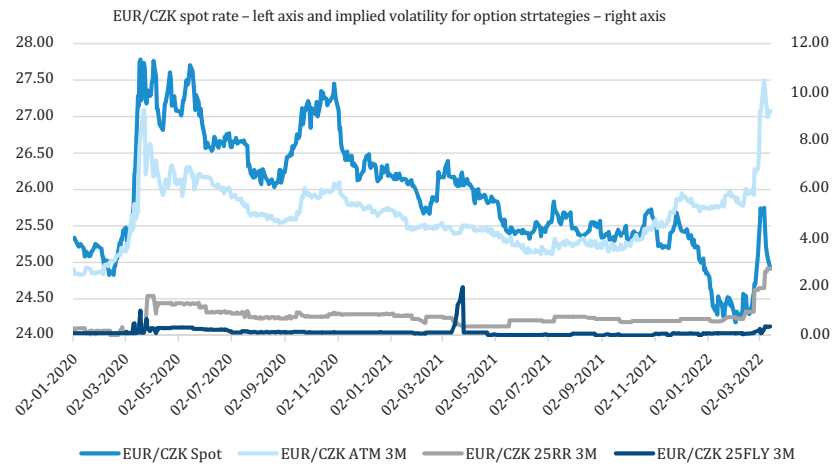
Source: Refinitiv.

Chart 4. EUR/HUF currency market between 2020–2022



Source: Refinitiv.

Chart 5. EUR/CZK currency market between 2020–2022



Source: Refinitiv.

The charts illustrate two tendencies. First one that the 2022 war had stronger impact than the first wave of COVID-19 (the evidence for that is a reaction of the option market). Second one that FX option prices reacted much stronger in frontal

countries than in Czech Republic. The reaction was twofold: firstly, local currency depreciation was followed by an increase of the expected volatility, skewness and kurtosis. Secondly, one observed a correlation rise in relation to option strategy prices representing higher moments of the distribution (table 3).

Table 3. Change of rates and Pearson correlations for CEE currencies during the war in Ukraine

Period 24.02–14.03.2022	EUR/PLN	EUR/HUF	EUR/CZK
Change of FX rate (Spot)	3.6%	4.3%	1.4%
Change of 3M ATM volatility (ATM)	5.6 pp	5.0 pp	3.4 pp
Change of 25-delta 3M risk reversal (RR)	2.8 pp	2.1 pp	1.8 pp
Change of 25-delta 3M butterfly (FLY)	0.1 pp	0.3 pp	0.3 pp
Correlation (dSpot, dATM)	63%	70%	52%
Correlation (dATM, dRR)	81%	86%	8%
Correlation (dATM, dFLY)	64%	37%	40%

Source: own calculations based on Refinitiv data.

The war as a black swan event caused a depreciation of assets vulnerable on market sentiment (i.e. emerging currencies), an increase of uncertainty (market volatility), augmented non-normality of a density function and a correlation rise. The latter phenomenon presents table 4.

Tabela 4. Korelacja Pearsona pomiędzy dziennymi zwrotami kursów walut CEE

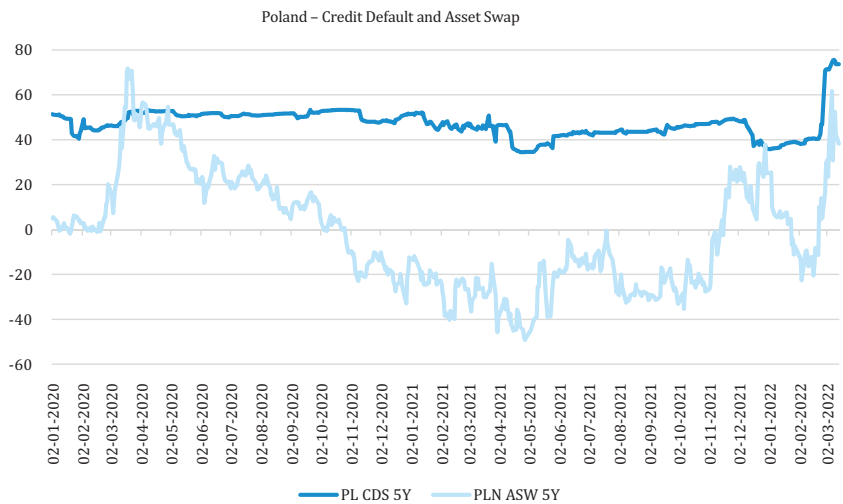
	The first wave of COVID-19			Period between 05.2020–01.2022			The first 3 weeks of UA–RU war		
FX rate	EUR/PLN	EUR/HUF	EUR/CZK	EUR/PLN	EUR/HUF	EUR/CZK	EUR/PLN	EUR/HUF	EUR/CZK
EUR/PLN	1			1			1		
EUR/HUF	56%	1		49%	1		92%	1	
EUR/CZK	71%	62%	1	48%	46%	1	74%	74%	1

Source: own calculations based on Refinitiv data.

The crisis periods imply higher correlation, but the war in Ukraine has higher impact than COVID-19. According to Smales (2022), the co-dependence on the financial market is stronger during the turbulence periods. The reason for that are contagion effects that favour spill-over of negative shocks between the markets.

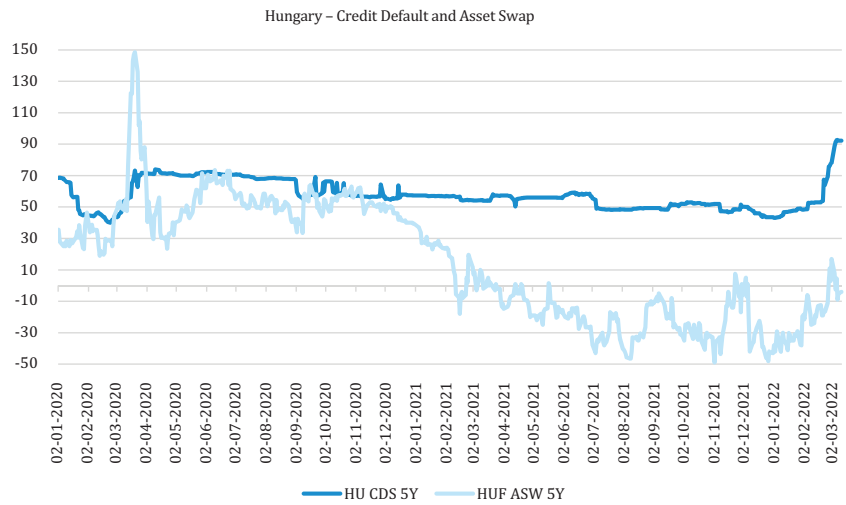
Turbulences on the currency markets were accompanied by the rise of a credit sovereign risk. The evidence for that are prices of Credit Default Swap and Asset Swap Spread. The first is an option on issuer bankruptcy, the latter is a difference between a bond yield and a swap yield of the similar duration. The change of the prices of the above mentioned instruments for Poland, Hungary and Czechia are presented on charts 6–8.

Chart 6. Polish credit risk between 2022–2022



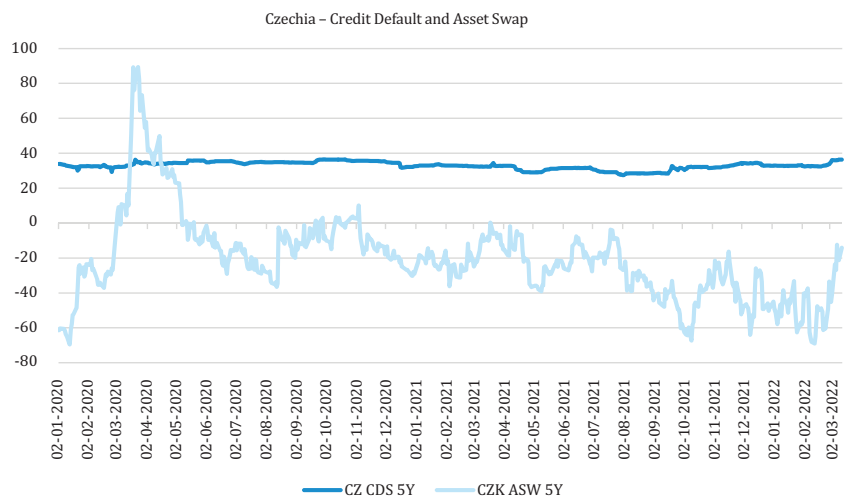
Source: Refinitiv.

Chart 7. Hungarian credit risk between 2020–2022



Source: Refinitiv.

Chart 8. Czech credit risk between 2020–2022



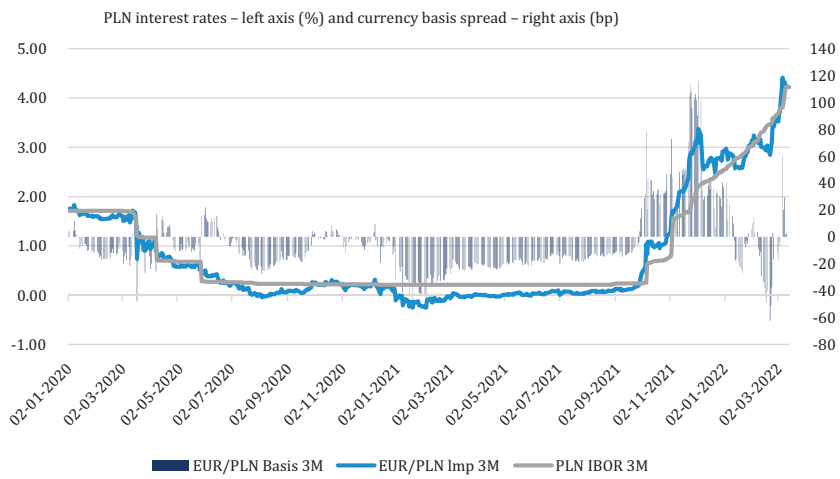
Source: Refinitiv.

After February 24, 2022 the price of Polish CDS rose by 35 bp – a few times more than in March 2020. ASW increased by 80 bp –10 bp more than during the first wave of the pandemic. According to that criterium the impact of the war was stronger than COVID-19. For Hungary the impact of the war on CDS prices was also stronger than the pandemic (40 bp vs 30 bp); however, Czech CDS prices were insensitive to both crises. Nevertheless, both Hungarian and Czech bonds depreciated in March 2020 in contrary to March 2022 when this price change was very small.

A variability of reaction of the analysed instruments results from different market liquidity – CDS are less liquid than treasury bonds and Polish market is bigger than Hungarian and Czech. The higher liquidity means stronger impact of decisions taken by non-residents affected by a rise in risk aversion.

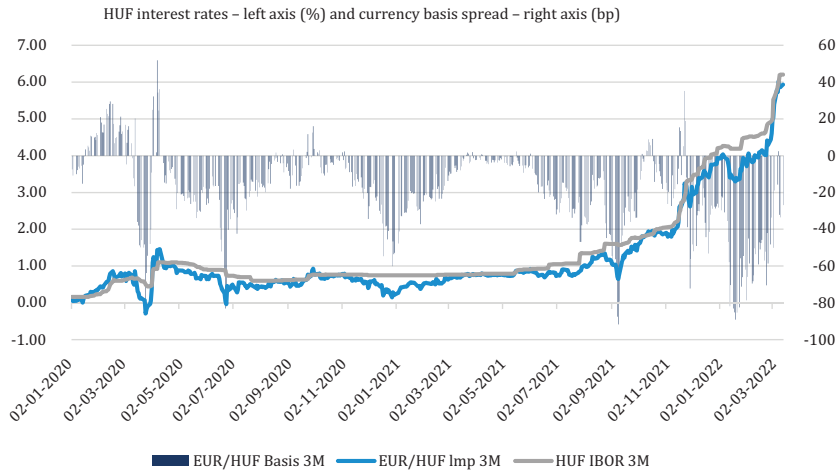
Market flows in foreign exchange and fixed income markets in small open economies with own currency and liberal currency law are affected prevailingly by non-residents. Non-residents invest in local assets using borrowed or bought local currency what shapes their risk profile. The borrowing is performed through currency swaps (FX Swap and CCBS) and the purchase directly on a spot market. Moreover investors use carry trading techniques: borrowing a low-yield currency and converting it to a high-yield currency. The balance of these flows can be observed by a comparison of interest rate implied from swaps and local interest rate benchmark. Charts 9–11 present interest rate implied from 3-month FX Swaps in euro against local currency. These rates are compared with local benchmarks: WIBOR in Poland, BUBOR in Hungary and PRIBOR in Czech Republic. The difference between the implied rate and the benchmark is called a currency basis swap.

Chart 9. Cross-border EUR/PLN liquidity between 2020–2022



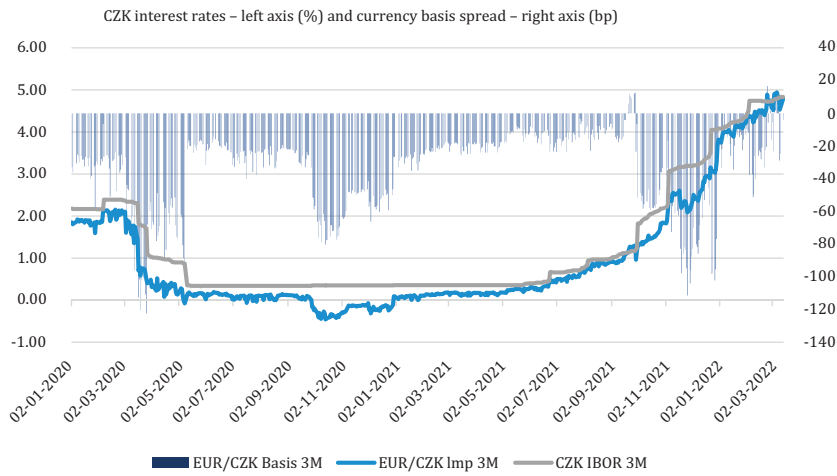
Source: own calculations based on Refinitiv data.

Chart 10. Cross-border EUR/HUF liquidity between 2020–2022



Source: own calculations based on Refinitiv data.

Chart 11. Cross-border EUR/CZK liquidity between 2020–2022



Source: own calculations based on Refinitiv data.

For the majority of analysed time series, the currency basis spread is slightly negative what means that non-residents can borrow a local currency below the benchmark rate. It is caused by constantly increased demand on carry trading in order to invest in high-yield currency what decreases its interest rate. It is worth adding that in the same period, the long-term currency basis recorded on CCBS market is slightly positive due to diminishing significance of CHF mortgage and quantitative easing in Eurozone. The charts show that natural trans-border flows were disturbed in Poland in autumn 2021. Especially in December 2021 and after the outbreak of the war in Ukraine one observed a sudden rise of the currency basis. These phenomena are accompanied by zloty depreciation and volatility rise. It is an evidence of usage of the FX Swap market to borrow zloty in order to sell it (so called short selling).

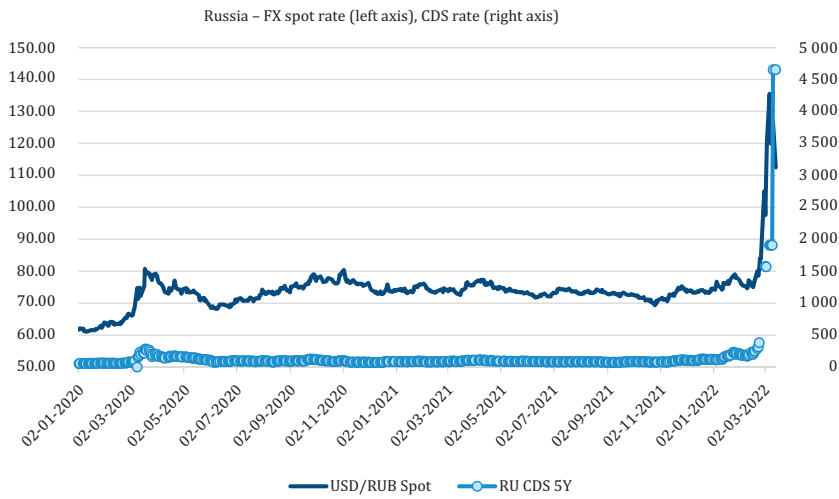
The outbreak of the war brought a high interdependence between the currency basis spreads in CEE countries. The Pearson correlation between the daily changes of the spreads rose from 10% to 40%. It is a natural reaction for unanticipated turbulences on the financial market.

4. Reaction on the Russian and Ukrainian financial market

The Russian and Ukrainian markets are less transparent and more difficult to analyse due to the limited number of available instruments and the lower liquidity of them. The only liquid instruments are FX Spot and CDS. One should notice non-liberal currency law in Ukraine what excludes non-residents' activity on that market. Borrowing hryvna is forbidden for non-residents in order to hamper speculative attack. As a consequence a market is divided into two parts: out of Kiev and out of London. The latter has limited liquidity and focus on NDF contracts (non-deliverable forwards).

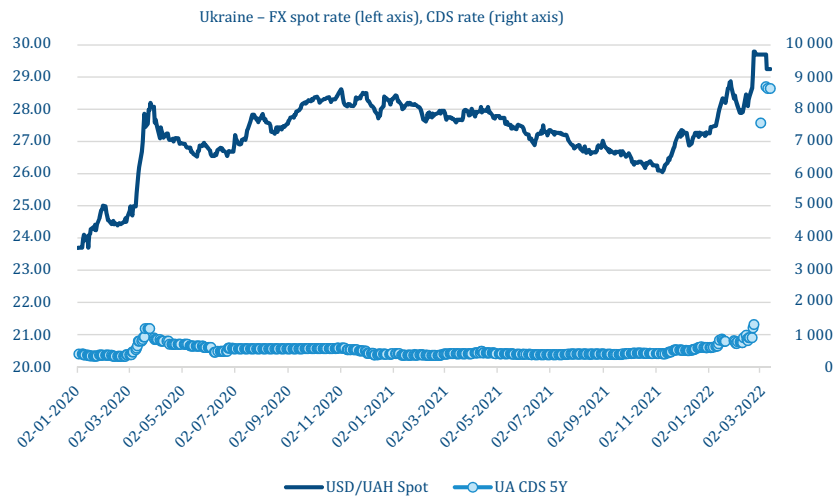
2020–2022 prices of FX Spot and CDS in Russia and Ukraine present the following charts (12–13).

Chart 12. Russian market between 2020–2022



Source: Refinitiv.

Chart 13. Ukrainian market 2020–2022



Source: Refinitiv.

The aggression on Ukraine had huge impact on the risk perception on the Russian market. It is clearly visible if we compare market reaction for both exogenic shocks: the outbreak of pandemic and the outbreak of the war. Between February 24 and

March 14 the rouble depreciated by 40% and CDS prices jumped 12 times. It is strictly connected with a downgrade of Russia to the junk level and a freeze of the Russian foreign reserves. The Russian market lost its liquidity and non-residents lost an access to the local market. On contrary the Ukrainian foreign exchange rate was stable due to the currency law constraints. Nevertheless, the credit risk of Ukraine increased heavily: CDS prices since February 21 (the announcement of the Russian approval of the independence of Donbas quasi-republics) rose 10 times A discontinuous rise of the CDS prices. deserves a special attention: after a few days of no trading the marked opened with a gap. Discontinuous jump is an evidence of a reaction to the unprecedented event that changes the scale of perceived risk. Such reaction is typical for black swan events.

5. Comparison of volatility on the analysed financial markets

In order to assess the scale of the black swan event a realized volatility just before and just after the event was checked. The time series was split into 5 sub-periods:

- a period just before the outburst of the COVID-19 pandemic (January – February 2020)
- the first wave of COVID-19 (March – April 2020)
- a period of the relative tranquillity between the first wave of COVID-19 and a start of tensions on the Ukrainian border (May 2020 – December 2021)
- a period just before the outbreak of the war (January – February 2022)
- first weeks of the war (24.02–14.03.2022).

Table 5 consists of the realized volatility (annualized standard deviation calculated on the log-returns – SD p.a.) split to 5 sub-periods and 6 analysed currency pairs.

Table 5. Realized annual volatility – broken down into 5 sub-periods

SD p.a.	EUR/USD	EUR/PLN	EUR/HUF	EUR/CZK	USD/RUB	USD/UAH
before COVID-19	4.8%	4.0%	5.3%	4.3%	11.3%	8.8%
COVID-19	12.2%	11.2%	11.7%	15.5%	36.6%	13.4%
between COVID-19 and WAR	5.9%	5.8%	6.6%	4.9%	11.4%	4.9%
before WAR	6.7%	7.6%	10.1%	6.9%	21.6%	11.5%
WAR	12.6%	19.6%	21.6%	12.4%	142.9%	6.5%

Source: own calculations based on Refinitiv data.

The both analysed crises brought a severalfold rise of the realized volatility. For 4 currencies (apart from CZK and UAH), the war meant higher FX instability than the first wave of the pandemic. Relatively low volatility of EUR/CZKiIs because Czechia is not a frontal country. In turn the low scope of hryvna instability during the Russian aggression is related to the non-liberal currency law that excludes speculative attack realized by non-residents. In such environment stabilising activities performed by the Ukrainian central bank were efficient.

In order to assess consequences of a black swan event one should take into account not only a scope of instability, but also a scope of unpredictability of the event (Aven 2013). The latter can be measured as a relation between volatility before and after the event. Increased volatility is an evidence of augmented disequilibrium between demand and supply. The disequilibrium comes from the shock connected with the unpredictable event. Market participants have to revise their expectations. The revision modifies market flows what has a severe impact on the price instability.

The consequence of the increased volatility is the occurrence of data that were incalculable on the basis of the past observations. For example, one observes daily returns exceeding standard daily returns expected on the basis of the past (historical) variance of the rate. The returns are located in a fat tail of the forecasted density function. It means that risk assessment performed before the event was significantly underestimated. The error in risk assessment is crucial for events classified as black swans.

Table 6 presents a quotient of a maximal absolute return after the event and a standard return estimated on the basis of the historical volatility calculated just before the outbreak for both events and 6 currencies.

Table 6. Relation between the expected volatility and the maximum daily return after the occurrence of the event

	EUR/USD	EUR/PLN	EUR/HUF	EUR/CZK	USD/RUB	USD/UAH
COVID-19	6.9	8.5	5.3	13.7	12.0	3.3
UA–RU war	3.8	4.6	4.2	4.2	13.6	2.1

Source: own calculations based on Refinitiv data.

The above comparison shows that pandemic caused stronger negative impulse for all currencies apart from rouble. In theory of the black swan it is an evidence that the pandemic was a greater shock than the war. Undoubtedly the period between the first infection in China and the outbreak of the pandemic was shorter than between the first tensions on the Ukrainian border and the outbreak of the war. Apart from that the pandemic was a brand new phenomenon in a globalized world since the Spanish influenza in 1918 and the war in Ukraine started in fact

in 2014 with annexation of Crimea. The only currency affected much stronger by the war was rouble. The market did not expect such strong sanctions against Russia, including SWIFT disconnection, freezing of foreign reserves and massive withdrawal of foreign business in Russia (Astrov et al. 2022).

Conclusions

Interpretation of the Russian attack on Ukraine as a black swan event is controversial, especially for those who treat the attack as a continuation of the war started in 2014 and for those who forecasted the aggression on the basis of the military concentration on Ukrainian border since late 2021. For others it was a big surprise and the evidence for that is a large impact on the prices of financial assets. That is a proof of not fully discounted forecasts related to the outbreak of the war. In comparison to the first wave of COVID-19 pandemic, the Russian invasion caused higher volatility levels, but lower relation between the volatility after and before the event. The impact on financial markets is therefore stronger for the war than for the pandemic, but the latter was a bigger surprise. The lower surprise related to the war can be connected with the intelligence forecasts that brought non-zero probability of the outbreak. Due to that, the more precise term for the 24 February event is "a grey swan". A grey swan is a phenomenon that has a huge impact and a low probability of the occurrence, however should be taken into account as a possible scenario (Craighead 2011). Moreover, the pandemic had a global impact and the war in Ukraine affects overwhelmingly the countries engaged directly and indirectly in the conflict.

A low probability of occurrence is strictly connected with a low probability of its consequences on the financial market. Forecasting of a black swan is obviously not possible. However, ex post it is possible to assess if the event was surprising and its impact was large for a society. One of the methods allowing to do so is the analysis of the financial market reaction. The financial market, due to a constant risk management and a process of discounting the future events, is in fact a place of probability trading. Changes of prices are proportional to the significance of observed events and a scale of their socio-economic consequences. It proves a high informational value of the financial market.

Literature

Abettan S., Hieminga G., Patterson W., (2022), *Carbon prices in the EU crash despite rising fossil fuel prices*, ING Economic and Financial Analysis, March 7.

Antipova T., (2020), *Coronavirus pandemic as black swan event*, [in:] International Conference on Integrated Science, Springer, pp. 356–366.

Astrov V., Grieveson R., Kochnev A., Landesmann M., Pindyuk O., (2022), Possible Russian Invasion of Ukraine, Scenarios for Sanctions, and Likely Economic Impact on Russia, Ukraine, and the EU Policy.

Aven T., (2013), *On the meaning of a black swan in a risk context*, Safety Science, 57, pp. 44–51.

Craighead S., (2011), *Stress and Resiliency Testing: Mandelbrotian Grey Swan Scenarios*, Conference Paper, 23 January, https://www.researchgate.net/publication/268801892.

Goldhub, (2020), *Investment Update: Gold prices swing as markets sell off*, March 19, https://www.gold.org/goldhub/research/gold-prices-swing-as-markets-sell-off.

Korhonen I., (2022), *Economic fallout from the war*, Bank of Finland Bulletin.

Liadze I., Macchiarelli C., Mortimer-Lee P., Juanino P.S., (2022), *The Economic Costs of the Russia-Ukraine Conflict*, NIESR Policy Paper, 32, March 2.

Smales L.A., (2022), *Spreading the fear: The central role of CBOE VIX in global stock market uncertainty*, Global Finance Journal, 51, 100679.

Taleb N.N., (2007), *Black Swans and the Domains of Statistics*, The American Statistician, 61:3, pp. 198–200.

Taylor J.B., Williams J.C., (2009), *A black swan in the money market*, American Economic Journal: Macroeconomics, 1(1), pp. 58–83.