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Faculty of Social Sciences

School of Economics and Business Administration

Artem Lishchuk, Roman Kyrylchenko

THE TRANSFORMATION OF THE UKRAINIAN GOVERNMENT BOND MARKET DURING WARFARE: EVIDENCE FROM THE RUSSIAN INVASION OF UKRAINE IN 2022

Bachelor Thesis

Supervisor: lecturer Mark Kantšukov

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We have written this Bachelor Thesis independently. Any ideas or data taken from other authors or other sources have been fully referenced.

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Introduction

Financial markets play a critical role in modern economies, managing the allocation of resources, transferring and sharing risks, and providing economic stability. Bond market is particularly significant as a mechanism for raising capital for governments, corporations, and other entities. According to OECD's global debt report (2024), the total outstanding amount of government and corporate bond debt by the end of 2023 amounts to 100 trillion USD, making it the biggest financial market globally. Governments and companies heavily rely on bonds as a way to secure financing, while investors view them as a means to diversify risk. However, during periods of crisis, such as warfare, the bond market – previously considered relatively safe – faces significant stress and uncertainty (Banerjee, et al, 2024). Wars provoke economic instability, impacting investor confidence and governmental policies. Warfare in the modern world is, unfortunately, not an unusual occurrence, and understanding how the bond market reacts during such times is vital for participants in affected economies.

This study addresses a significant research gap. While numerous studies explore the effects of war on economies and financial markets (Assaf et al., 2023; Banerjee et al., 2024; Fernandez, 2008, etc.), detailed analyses of bond market responses to warfare remain limited, particularly in the context of emerging economies like Ukraine. Also, since the beginning of the 21st century, there have not been any major warfare conflicts, the latest empirical studies go a long way to the past and do not take into account the current state of the modern world. There is some existing research examining the effects of warfare on bond markets, such as during the World War II (Frey & Kucher, 2000), the Israel-Hamas war (Martins, 2024; Kollias et al., 2010) or during Spanish Civil Revolution (Battilossi et al., 2022). Also, considering the fact that the full-scale Russian Ukrainian conflict began in 2022, there is not enough specific literature that focuses on the Ukrainian bond market behaviour, peculiarities and adaptation. Additionally, some studies focus on the transformation of financial markets in countries affected by major terrorist attacks that led to war conflict, like the case of the United States on September 11, 2001 (Chesney et al., 2011).

The aim of this bachelor's thesis is to identify and map the transformations of the government bond market to their potential causes, on the example of Ukraine during the Russian invasion of Ukraine. The authors refer to the period of full-scale Russian Ukrainian war period, meaning timeframe from 24th February 2022 (Russian invasion) to 21st February 2025 (the last observations captured by authors). Under transformations the authors consider fundamental shifts in bond yields complemented by insights from the economic environment. By integrating empirical findings and historical comparisons, this research contributes to a

deeper understanding of how bond markets behave during periods of conflict. Such insights can contribute to strategies for managing bond markets in other regions experiencing similar crises, providing valuable lessons for future applications. To achieve the aim, the authors formulated the following research tasks:

1. to discuss how the government bond market may transform under the conditions of warfare from theoretical macroeconomic perspective;
2. to map the bond investors' behavioural patterns onto the conditions of warfare;
3. to provide an overview of the previous academic literature on the topic of bond markets' transformation during wars;
4. to collect the data about the Ukrainian government bond market and present the methodology for empirical research;
5. to run the structural break tests identifying shifts in the government bond yields data;
6. to interpret identified structural breaks connecting them to potential causes.

This bachelor thesis has certain limitations. First, other financial markets (such as equities or currencies) and broader macroeconomic impacts are outside the scope, although they are acknowledged as part of the overall economic discussion. Second, the analysis is constrained by the availability of data during an ongoing conflict; the war's full long-term effects (for example, on post-war recovery or on investor behaviour after the conflict) cannot yet be observed and thus fall beyond this thesis. By examining Ukraine's experience, policymakers and government officials may benefit from empirical evidence on how to manage national debt issuance during wartime and how to sustain public confidence in government securities. The thesis illustrates the importance of timely fiscal and monetary responses, such as imposing capital controls, adjusting interest rates, or issuing war bonds. Central banks and financial regulators can benefit from the findings of the thesis by gaining a deeper understanding of when and why structural breaks in bond yields occur, helping them to plan more effective market interventions. The thesis highlights how foreign and domestic investor groups responded to warfare, allowing regulators to anticipate shifts in demand and adjust liquidity and risk management policies accordingly. This bachelor thesis can help institutional and retail investors to help reassess portfolio risks and identify potential opportunities or exit points during crises.

The structure of the thesis comprises the theoretical and empirical part. Chapter 1 provides a broad theoretical perspective on bond market transformation during warfare. It opens by examining the macroeconomic impacts of war on financial markets, laying out why conflicts tend to influence factors like interest rates, inflation expectations, and default risk

(Subchapter 1.1). It then explores how investor behaviour adapts under extreme uncertainty – for example, whether investors engage in flight-to-quality, panic selling, or speculative buying of riskier assets like war bonds (Subchapter 1.2). Subchapter 1.3 of the chapter offers a review of previous empirical studies on war and financial markets, highlighting findings from studies on earlier conflicts and crises that form the basis for Ukraine's case. Together, these theoretical foundations establish what transformations one might anticipate in a bond market under wartime stress. Chapter 2 then presents the empirical analysis of the Ukrainian government bond market during the Russian Ukrainian war. Subchapter 2.1 describes the data collected (including an overview of Ukraine's government bond market conditions before the conflict) and the methodology of the research, detailing how the structural break tests is conducted. Subchapter 2.2 reports the results of the empirical research and Subchapter 2.3 provides a discussion of the findings – for instance, how bond yields moved during key phases of the war, how the volume and terms of bond issuance changed, how the investor base of Ukrainian domestic government bonds shifted over time, and what were the potential main causes for this behaviour. This discussion also compares empirical results with the patterns suggested by the theory and prior literature. Finally, the conclusion part synthesises how the war affected Ukraine's government bond market, evaluates whether the research aim was achieved, and discusses the implications for theory and practice.

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Key words: Government bond market, warfare, investor sentiment, geopolitical uncertainty, flight-to-safety, flight-to-liquidity.

1. Transformation of government bond market during warfare – theoretical perspective

1.1. Impact of warfare on the government bond market from macroeconomic perspective

Bonds are financial instruments that are generally considered as relatively safe assets due to the predetermined nature of the stream of future payments. "In economic theory, the yield on a bond is the 'pure' rate of interest … plus a premium for uncertainty which takes into account (a) the risk of default by the borrower and (b) the lender's expectations of inflation and/or [currency] depreciation, with the size of the premium generally being larger

the more remote the redemption date" (Ferguson, 1999, p. 16). From an investment perspective, bondholders generate returns through interest payments (in the case of coupon bonds), principal repayment at maturity, and trading on secondary markets. From the risk standpoint, the authors suggest that bond investors are exposed to the two main types of risks: 1) risks associated with the ability of the borrower to complete the timely principal repayment and interest payments – credit risk; 2) risk of decline in the market price of the credit security triggered by a move upward in the prevailing rates for new debt instruments – interest rate risk.

Government-issued bonds carry a distinct type of risk due to the unique nature of sovereign debt obligations. Unlike corporate debt, sovereign debt (debt issued by countries) is not subject to the same legal enforcement mechanisms. However, sovereign bonds are generally associated with low or negligible default risk, as their repayment is typically more dependent on the government's willingness to honour its commitments rather than its financial capacity to do so. (Eaton & Gersowitz, 1981; Bulow & Rogoff, 1989)

Warfare is a major catastrophic event that inevitably leads to the increase in political and geopolitical uncertainty, which are crucial factors influencing bond markets by changing the expectation of future inflation, growth and/or creditworthiness of the borrower or indirectly through the investment sentiment (He, 2023). The period of warfare affects the country's economy through five channels: potential loss of independence and/or territory; heavy casualties, accompanied by the labour migration and, potential reorganisation – due to the mandatory mobilisation efforts, etc; higher expenditures on defence; decline in the economic activity; increased uncertainty and reduced optimist expectations (Caldara & Iacoviello, 2022). Caldara and Iacoviello (2022) state that the increase in the geopolitical risk leads to lower investment and employment in the economy, leading to the decline in the economic activity and, hence, decline in the economic growth. The perceived impact of the conflict on the national wealth has a direct impact on the yields on the bonds (Liadze et al., 2023).

As mentioned before, the key determinants of the bond yields are: expected growth, expected inflation and the creditworthiness of the borrower. The authors will start by introducing the macroeconomic consequences and spillovers that can be provoked by major geopolitical events and attribute them to the potential shift in the aforementioned variables and, consequently, on the bond yields.

GDP, which is often referred to as a measure of economic activity, consists of four components: consumption, investments, government spendings; net exports (Bureau of

Economic Analysis, 2020). The Table 1 below presents how each component of GDP is affected by warfare.

Table 1

Summary of changes in the components of GDP in times of warfare

Component of GDP	Source(s)	Change in times of warfare
Aggregate consumption	Shenderova (2023); Bloom et al., (2018); Nam et al., (2021); Feigenbaum and Li, (2015);	In case of warfare, or the increase in the macroeconomic and geopolitical uncertainty, the effect of the consumption smoothing occurs. It means that consumers adjust their spending habits in case of a changing economic situation. In case of warfare, consumers become worried about the future income loss or fewer return on assets, and become cautious, which leads to increased savings – called precautionary savings – instead of spending money. This results in the lower aggregate level of consumption.
Aggregate Investment	Binz, (2022); Wang et al., (2024); Stein and Stone (2013)	Companies are demand-driven in their investments, and in case of the increased uncertainty, they are unable to forecast future demand, and consequently decide to reduce capital investments; hiring; marketing, etc. Also, investments decrease through the real options channel due to the asymmetric adjustment cost of delaying investments.
Government spendings	Antolin-Diaz and Suriko, (2022); Authors' opinion	In times of warfare, the government spendings increase due to the heavy military expenditures; need for the social securities for the people affected by the war actions
Net exports	Mielcarzl et al., (2024)	Military conflicts disrupt supply chains and restrict trade, which leads to the decrease in international trade. Also, the destruction of infrastructure and labour shortages lead to the increase in imports.

Source: compiled by the authors

As it can be seen, in case of warfare, aggregate consumption, investment and net exports decrease leading to the significant decline in economic activity and the expectations of economic growth. Reduction in the expectations of economic growth should lead to the reduction in the bond yield. The other components of bond yield, however, are of bigger concern to the bondholders. Military conflicts bring huge inflationary consequences: labour shortages, commodity costs and the supply chain disruptions leading to inflation. (Mielcarzl et al., 2024) Inflation is one of the biggest concerns for bondholders, especially talking about long-term bonds, since it directly impacts the real value of fixed income payments from

securities. Due to reduced purchasing power of the future bond payments, higher returns are demanded by investors, causing yields to rise. In order to counteract inflation, the central bank of the country under such circumstances may increase interest rates, raising the yield required for newly issued bonds and making existing bonds less attractive, resulting in the decline in the prices of the latter ones (Abbas & Lan, 2020).

The only component of GDP that increases during the time of warfare is the government spending. The incremental spendings put a huge burden on a budget. In absence of the significant national savings, the government must bridge the gap between the budget revenues and expenses through additional inflows to the budget. The most common ways to ensure that is to raise taxes and/or issue debt. Levi (1988) notes that increase in taxes is negatively perceived among the citizens, and Gibbons (2014) notes that their unwillingness to fund the war only increases with the continuation of the conflict. Issuing bonds on the other hand, does not feel to the citizens as if they are directly contributing to the military endeavours, which allows to delay the pessimism to the time when the conflict ends (Mastanduno et al., 1989). Also, it creates other motivational factors for the domestic citizens and foreign investors for the conflict to end as soon as possible (Fujihira, 2000). Consequently, often, the governments rely on the public debt market to fund the spendings (Szkutnik & Wyłuda, 2022), which results in the increased total debt levels and accompanies with higher yield due to risk premia, lead to the high costs to service the debt, and provided that the warfare takes long time to recover, may put country's economy in a debt spiral, where government needs to borrow more money not only to stay afloat in a frontier, but also to service the existing debt. Bond investors assess the government fiscal stability and incorporate the risk of the government going default – whether due to inability or unwillingness to serve the existing or newly issued debt – by demanding higher risk premia. The authors of the bachelor's thesis indicate another method to finance the budget needs – foreign direct investments, which may help a country to keep their budget intact, however, the countries providing the help are going to cover the expenses.

A paper by Jeanneret (2015) illustrates how sovereign credit spreads widen in response to the heightened fiscal risks and economic uncertainty during crises due to the increased financial stress and fiscal vulnerabilities. Therefore, it can be assumed that countries facing geopolitical stress, as in the case of Ukraine, experience widened credit spreads that may reflect perception of higher risk related to fiscal instability or increased borrowing costs incorporated into risk premiums for riskier sovereign or corporate bonds.

Regarding the corporate credit spreads, worth noting that, the corporate profitability actually increases in the event of macroeconomic uncertainty (Binz, 2022). Kaviani et al. (2010), however, finds that corporate credit spreads for US companies increase with growth in the EPU (Economic Policy Uncertainty) Index in the United States, companies that are reliant on the government spendings, face strict government regulations or have high tax rate burden, are experiencing the biggest increase in their corporate credit spreads. Valenzula et al. (2024) expanded their research by noting that the positive relationship between the increase in the EPU index and the corporate credit spreads is "homogenous" across all markets – developed or emerging, however noted that the magnitude of relationship is much stronger in the emerging markets, counties with worse credit rating – meaning that increase in their corporate credit spreads should be higher.

Another aspect that is worth mentioning when discussing bond markets in times of elevated geopolitical risk concerns volatility transmission. Banerjee et al. (2024) stress that during increased geopolitical risk index (GPR), which is a quantitative measure of geopolitical uncertainty, bond markets rather play the role of volatility transmitter than receiver, conveying shocks to other financial markets. It means that during crises bonds amplify instability in the financial system, influencing other financial assets and markets. Alshammari et al. (2024) expanded the findings emphasising that the corporate bond market, in particular, plays a role of main volatility transmitter. For example, increased yields on corporate bonds, driven by geopolitical events, pushes up the cost of capital for companies. This potentially can lead to companies experiencing problems with financing their operations and declining stock prices. Bonds as transmitters of volatility in one way or another can also impact currency market, credit market and overall investor behaviour. Interestingly, the authors assume that such influence on other financial sectors can feed back into the bond market, since, for instance, declines in equity or currency markets can boost economic uncertainty in the country, and raise perceived risk in fixed income securities.

In summary, warfare leads to a contraction in economic activity by reducing consumption, investment, and net exports, while simultaneously driving up government spending. This deterioration in growth expectations puts pressure on the bond market. However, warfare also triggers inflationary pressures and forces governments to rely on debt issuance to finance rising military expenditures, pushing bond yields higher through increased risk premia. The combination of weaker economic growth, rising inflation, expanding fiscal deficits, and higher debt levels raises investor concerns about sovereign creditworthiness, causing yields and credit spreads to widen. Additionally, volatility in bond

markets during geopolitical crises amplifies risks across financial markets, further reinforcing the negative feedback loop on investor sentiment. On a corporate level, in a short-term the profitability should remain intact, however, the broader macroeconomic concerns, including ones regarding the potential destruction of the assets, and nationalisation, should lead to the increase in the corporate spreads as well (Raatikainen, 2023, Leigh et al., 2003). Overall, the macroeconomic disruption caused by warfare transmits directly to the bond market through lower growth expectations and indirectly through inflation, fiscal strain, and rising credit risk premiums.

1.2. Investors' behaviour patterns during periods of geopolitical distress

Investors are the driving force behind financial market dynamics, as their decisions directly influence liquidity, pricing, and the allocation of capital (Waldenström & Frey, 2002). The paper by He (2023) finds that investor sentiment is one of the main factors influencing the performance of financial markets. Understanding the investors' behaviour is necessary for analysing how the bond market transforms during periods of heightened geopolitical uncertainty and warfare. In this subchapter the authors explore the key behavioural patterns and strategies employed by investors interacting with the markets, when confronted with geopolitical risks.

"Entrepreneurs, market participants, and central bank officials view geopolitical risks as key determinants of investment decisions and stock market dynamics" (Caldara & Iacoviello, 2022, p.1), with Bank of England even noting that geopolitical risk is among the risk that may lead to the worst decline in the economic and financial markets (Carney, 2016). The distribution of information among all market participants is the primary mechanism through which real-world events, such as geopolitical shocks, are reflected in asset prices. Efficient Market Hypothesis states that asset prices at any given moment reflect all available information to actors, meaning that any movements in prices provide market participants with relevant information that forms their expectations about asset's performance. (Waldenström & Frey, 2002)

While a plenty of studies focus on debt and equity markets' reaction to shocking geopolitical events (e.g. Chesney et al., 2011; Fernandez, 2008; Frey & Kucher, 2000; Martins, 2024), it is important to understand that investors not only react to sudden geopolitical events but also attempt to anticipate future risks, often reshaping markets well in advance of a conflict's actual occurrence. The study by Granát (2023) highlights that investor sentiment and actions often reflect the probability of a conflict, rather than its actual outbreak, thus such anticipation already leads to pricing of the potential conflict beforehand. Therefore,

timely access to reliable and relevant information shapes how investors interact with financial markets and reallocate their capital. However, during periods of heightened uncertainty, market inefficiencies often emerge, reflecting either excessive investor reactions to news or a failure to fully incorporate new information into pricing models. This can occur for several reasons, including information overload, as geopolitical crises typically trigger a surge of breaking news, speculative reports, and official announcements, making it difficult for investors to process and interpret the data accurately. Additionally, behavioural biases may become more pronounced in such environments, leading to herding behaviour and emotionally driven decision-making. That said, this effect is often more significant in markets dominated by large investment funds than among individual investors, as institutional players tend to imitate each other's strategies while trading substantially larger volumes (Mauro et al., 2002; as cited in Waldenström & Frey, 2002).

Relying on macroeconomic theory, the authors can highlight the role of two primary mechanisms through which geopolitical uncertainty affects investors on the bond markets: risk premiums and liquidity dynamics. In the related literature, those mechanisms are reflected in several key effects: "flight-to-safety/quality", "flight-to-liquidity" and "flight-to-home", which broadly capture investors' reactions to different events and market conditions (e.g. Martins, 2024; Baur & Lucey, 2009; Beber et al., 2009; Wu et al., 2024 and others).

In context of the risk premiums, heightened geopolitical uncertainty increases investor risk aversion, exhibiting flight-to-safety effect (Agoraki et al., 2024), that should reduce yields on safe assets due to increased demand, at the same time risk premium for corporate and emerging markets bonds may rise. Investors may require higher compensation for holding bonds with greater risk suggesting potential default, lower credit rating or destabilisation of the market during geopolitical distress.

Concerning the dynamics of liquidity, the authors can note that geopolitical risks often lead to reduced market liquidity, particularly for riskier bonds. It happens because investors tend to prioritise assets with higher trading volumes, contributing to additional stress for less liquid markets. According to the study by Beber et al. (2009), market stress causes flight-to-liquidity dynamics. This shift causes sovereign bond yields to reduce while yields on more riskier assets, like corporate bonds, that face diminished demand, increase. As a result, credit spread widens reflecting liquidity premium and additional risk compensation during times of geopolitical uncertainty. Despite the fact that both credit quality and liquidity demonstrate positive correlation, making it difficult to determine the primary investors' concern (Ericsson and Renault, 2006), Beber et al. (2009) argue that specifically in times of

increased uncertainty on the market, striving for liquidity dominates over the flight-to-quality. Table 2 describes the aforementioned effects and their implications.

Table 2

Effects related to investor behaviour during market stress

Effect	Source(s)	The manifestation of the effect
Flight-to-quality/safety	Ahmed (2023); Bouri and Jalkh (2024); Beber et al. (2009); Agoraki (2024)	The flight-to-quality or flight-to-safety phenomenon occurs when investors shift their capital from riskier assets, such as equities, to safer ones with higher credit ratings like government bonds, gold, or stable currencies during periods of financial stress, heightened uncertainty, or geopolitical crises. This behaviour reflects the need to preserve capital and mitigate losses in turbulent times. The relationship between risky and safe assets can vary across different markets.
Flight-to-liquidity	Beber et al. (2009); Radde (2015); Li et al. (2019); Amihud (2002); Longstaff (2002)	The flight-to-liquidity phenomenon refers to investors' tendency to shift toward highly liquid securities during periods of financial stress or uncertainty, prioritising assets that can be quickly traded with minimal price disruption. This behaviour is driven by the desire to reduce exposure to illiquid positions and maintain rapid access to capital. The effect is particularly pronounced in emerging markets, where structural factors such as high transaction costs and information asymmetry exacerbate liquidity concerns. Consequently, this phenomenon can intensify financial instability by widening credit spreads and distorting asset pricing, highlighting the importance of liquidity risk in asset valuation and portfolio management during episodes of market turbulence.
Flight-to-home	Agoraki (2024); Hildebrand (2012); Gianetti and Laeven (2012)	The flight-to-home effect refers to a phenomenon observed during periods of financial crises or adverse economic conditions, where investors demonstrate a pronounced preference for domestic over foreign investments. This behaviour is driven by increased uncertainty and worsening liquidity and solvency conditions. This shift reflects a preference for markets where investors have better information or perceive lower risks. The effect also may amplify volatility in host countries that rely on foreign credit while stabilising the home countries.

Source: compiled by the authors

The globalisation and increasing integration of technology and financial markets have significantly eased cross-border capital flows, providing foreign investors with broader opportunities to allocate capital internationally. Agoraki et al. (2024) note the flight-to-home phenomenon takes place in case of increased geopolitical risk. This behavioural pattern

reflects preference for perceived safety and familiarity with the market. Authors also mention that the flight-to-home effect is even more pronounced in the emerging countries, which are often considered less stable and more vulnerable to external shocks, compared to the developed ones (Agoraki et al., 2024). The increase in the uncertainty in the country leads to the foreign investors relocating capital out of the country (Pastor & Veronesi, 2013). This can lead to a self-reinforcing cycle, where capital outflows intensify market instability, making investment into affected economies less and less attractive and deepening the overall economic impact of the geopolitical distress.

Despite the aforementioned risk-aversion effects driven by the investor sentiment that lead to the overall increase in the bond yields and decrease in bond prices of the country affected by the war and its corporations – Szkutnik and Wyłuda (2022) show that bond yields cannot increase indefinitely, and after falling for some time they plateau. Authors attribute this effect to the so-called “clientele effect”, which reflects the “differentiation of groups that purchase financial instruments” (Szkutnik & Wyłuda, 2022, p. 1). As risk-averse investors exit the market, they are often replaced by distinct groups, such as patriotic investors, who are motivated by a desire to support their country despite the potential for relatively low returns, and speculators, who are drawn by the high volatility and opportunities for short-term gains; also, in some cases the companies are forced to purchase bonds by the governments (Szkutnik & Wyłuda, 2022). Worth noting that investing in bonds during the warfare is often a bad decision, fundamentally, since, firstly, as will be shown in the next part of the research analysing the Frey and Kucher (2000) or Waldenström and Frey (2002) papers, the price of bonds reflect the current state of the conflict, not its expected outcome, and with warfare quickly changing its state, price may quickly turn around with new information from a frontline, secondly, Szkutnik and Wyłuda (2022) proved that yields on the bonds during the war are often below the CAPM line – indicating the required rate of return for the risk the assets have, meaning that bondholders are not compensated enough. Since speculators mostly focus on short-term gains, with the duration of the conflict, the demand from the speculators should reduce, and the only party buying bonds would be left – patriots (Szkutnik & Wyłuda, 2022).

Often, the government uses the diaspora to obtain the cheap financing, for example, after the Hamas invasion in Israel in 2023, the Israeli diaspora lent to the government in a lower yield than before the war, while the commercial market reacted in an opposite way (Bradley et al., 2024; Szkutnik & Wyłuda, 2022; Martins 2024). The reason for this difference is so-called “patriotic discount", which means that the diaspora bonds combine gift

and charity, and, in bad times, investors pay a premium, but in good times, the government pays them back generously (Bradley et al., 2024). Other academicians (Gande & Puri, 2005 and Ketkar and Ratha, 2010) argue, however, that there are rational reasons for a discount, such as better awareness of the situation in the home country; willingness to the accept the domestic currency; perception that the government would rather default on the foreign bonds, rather than domestic.

In summary, Subchapter 1.2 explains how heightened geopolitical risk reshapes bond markets through the lens of the investors' behavioural patterns. Two channels transmit this uncertainty: risk-premium anxiety and liquidity-seeking. These two channels manifest in three recurring patterns: flight-to-safety, flight-to-liquidity and flight-to-home effects. Once the most risk-averse holders leave, a "clientele effect" sets in stabilising prices.

1.3. Overview of previous studies

In this subchapter, the authors review the findings of previous studies on the transformation of the bond market under heightened geopolitical risk, which, according to Caldara and Iacoviello (2022) refers to the risks associated with terrorism, armed conflict, and international tensions. The conflicts discussed range from short-lived engagements with limited participants and minimal global impact, such as the Israel-Hamas confrontations (Martins, 2024; Kollias et al., 2010) and the September 11, 2001 terrorist attacks in the United States (Chesney et al., 2011), to more protracted and large-scale conflicts, including World War I (Fergusson, 1999) and World War II (Frey & Kucher, 2000). Additionally, regional conflicts, such as the Russo-Japanese War (Fergusson, 1999) and the pre-war period of instability in Spain during the Spanish Second Republic (Battilossi, 2011), are examined. The purpose of this subchapter is to identify underlying patterns and assess their relevance to the broader theoretical framework established in earlier subchapters. Each of these historical cases exhibits both similarities and differences, enabling the identification of key theoretical factors likely to influence the Ukrainian bond market. In order to systematise the insights provided by the aforementioned authors, it was decided to compile a summary table (Table 3) that demonstrates some key findings from the discussed studies.

Table 3

Summary of key findings of previous empirical studies

Source(s)	Conflict	Main findings
Battilossi (2021)	Spanish Second Republic, pre-Civil War	Flight-to-safety effect: Investors switched from stocks to government bonds. The bond market experienced less volatility compared to the equity market, with less pronounced losses during significant political events (e.g.,

	period (1931–1936)	a 10% drop in 1931 and 9.6% in 1936). Yields in the bond market started rising in anticipation of the "possibility of radical changes in the political" landscape, reaching the highest level a year after the general elections, and afterwards recovering to the pre-elections level. No "flight-to-liquidity effect"
Chesney (2011)	Various global terrorist attacks (77 events, 1990–2001)	Different bond markets experienced both positive and negative returns in response to the terrorist attack. The U.S. Government Bond Index was the least affected. In contrast, global and European bond markets reacted negatively across all periods
Ferguson (1999)	World War I (1914–1918), Russo-Japanese War (1904–1905)	At the outbreak of World War I, government bond markets experienced a sharp and widespread decline in prices, as uncertainty and geopolitical risk intensified. In response, the affected governments issued substantial volumes of public debt to finance military expenditures. Notably, British consols demonstrated relative stability amidst the broader market turmoil.
Waldenström and Frey (2002)	World War II (1939–1945)	The study focuses on the international bond prices in the unregulated Swedish exchange. Large drop at, or slightly before, the start of World War II, and the subsequent rise throughout World War II. Significant difference in the volatility of returns depending on the role that the countries played in the conflict and its dynamics. The specific country's bond prices largely followed the changes in the warfare landscape with German rising from 1939 – 1941 and falling afterwards, and others showing opposite movements. The bond prices of the occupied countries (e.g., Denmark) have never gone to zero.
Frey and Kucher (2000)	World War II (1939–1945)	The study focuses on the international bond prices in the Swiss bourse. A sharp drop in the bond prices before the start of World War II, with further stabilisation during the conflict. The specific country's bond prices largely followed the changes in the warfare landscape with German and Austrian rising from 1939 – 1941 and falling afterwards, and others showing opposite movements. The bond prices of the occupied countries (e.g. France) have never gone to zero. The possibility of the earlier end of conflict had a positive impact on bond prices.
Kollias et al. (2010)	Israel-Hamas war (2008)	Due to the statements made by the confronting sides before the beginning of the warfare, appreciation of the government bond index in 3-day and 6-day windows was observed indicating positive and statistically significant returns of bonds. However, after the armed escalation of the conflict (26 December, 2008) the study highlights an opposite movement.
Martins (2024)	Gaza War (2023)	The bond market experienced negative and statistically significant abnormal returns immediately after the terrorist attack. In the short-term window sovereign bonds were showing negative abnormal returns throughout the first week of the conflict (-6.34% in the first day of invasion, -8.56 % and -7.39 % cumulative negative abnormal returns

		in the 3 and 5 days following the start of invasion. In the 10-days window reversed movement was observed, with dominating positive abnormal returns.
Giesecke et al. (2011)	Various periods of major uncertainty from 1866 to 2002, including two World Wars	Default rates of organisations on corporate bonds significantly increase during periods of geopolitical crises.

Source: compiled by the authors

Across the historical cases analysed it was decided to identify several commonalities in how bond markets reacted to geopolitical crises. One of the consistent observations is the sharp increase in risk premiums during periods of conflict or uncertainty (Ferguson, 1999; Waldenström & Frey, 2002), which may be a response to increased government spending associated with war that leads to higher interest rates (Barro, 1974). Notably, the rise in yields was observed either as a response to crisis anticipation, or after the conflict outbreak. During the conflict, in particular, due to increased probability of the crisis resolution, yields tend to gradually decline to the pre-war level, with only one notable exception of World War I, as described in the Fergusson (1999). In World War I, in contrast to the newer conflicts, the bond yields remained elevated even after the conflicts had been resolved, and the rise in yields was so rapid that Fergusson (1999) notes that the London Stock Exchange was forced to stop trading. In the opinion of the authors of the bachelor thesis, it may be attributed to a couple of things, such as the anticipation by the agents of the other newer conflict, which results from the increased informational awareness with time. In a context of the Russo-Ukrainian warfare it's even more relevant, since with the technological advancements and advent of faster trading, the agents may monitor the change in the state of the conflicts, and rapidly buy or sell positions. Mostly, fluctuations in bond yields mirrored the situation on the frontline or the changes in political uncertainty. From investors' perspective, premiums reflect the risk of borrower's default and lender's perception of upcoming inflation, which is a rational response to uncertainty. These increased yields were followed by price drops due to the inverse nature of their relationship. Additionally, bond returns and yields during these periods of geopolitical stress show notable volatility, as uncertainty disrupts normal market dynamics (Ferguson, 1999; Martins, 2024; Waldenström & Frey, 2002).

Similarly, investor sentiment demonstrates a predictable pattern of risk-aversion during crises. Securities on financial markets, bond markets, in particular, of neutral or stable economies experience surge in demand as in the case of Switzerland or Sweden during the

Second World War (Frey & Kucher, 2000; Waldenström & Frey, 2002). This tendency aligns with behavioural finance theories, discussed in previous subchapters, emphasising the dominance of loss-aversion, flight-to-liquidity dynamic and collective risk aversion during uncertain times. It can be highlighted that both Chesney et al., (2011) and Martins (2024) demonstrated in their studies some similar peculiarities in bond markets' behaviour, being in line with each other from immediate reaction (capital transition) to recovery and resilience. Talking about flight-to-quality and flight-to-liquidity effects, it is important to note that the United States is one of the most developed, stable and liquid financial systems in the world, meaning that US government bonds' reaction to such geopolitical shocks cannot be fully comparable with less-competent economies, like Ukraine or other countries mentioned in this paper. Emerging markets can be more susceptible to this type of distress due to factors like limited market liquidity, higher default risk perception and dependency on external financing. Findings from these papers induce keeping in mind the dominance of the drive for liquidity over quality in times of crises, argued by Beber et al. (2009). Despite substantial differences in economies' size and level of development, the authors believe that insights about some tendencies related to investor sentiment may be reflected in other countries regardless of these factors.

In the context of government policies and interventions into the bond market during the periods of heightened geopolitical stress, some tendencies may also be noticed. Such actions are usually aimed at maintaining market stability, such as in the case of Israel, when the Bank of Israel cut the interest rate by 75 bps, which could potentially lead to negative abnormal bond returns after the beginning of the confrontation (Kollias, 2010). During World War II the majority of western countries affected by war implemented significant market interventions, applying substantial restrictions related to listing rules and price movements, or even closing trade on bond markets (Waldenström & Frey, 2002). Also, the Finnish government decided to introduce a moratorium of its debt and delayed repayments to investors (Waldenström & Frey, 2002), which, as assumed by the authors, was done due to a severe economic downturn and desire to conserve cash flows, prioritising essential expenditures at that time. Similarly, to aforementioned countries, but in a less radical way, the Spanish Ministry of Finance attempted to commit a few interventions in order to stabilise the bond market during the most intense turmoil. For example, in 1931 and 1936, the authorities at the Madrid Stock Exchange imposed price floors on government bonds, effectively transforming them into put options. This measure was intended to shield investors from substantial losses (Battilossi et al., 2022). These actions could help bond prices to

restore their initial level as before the beginning of the crisis. It is worth noting that the economic conditions faced by Spain after the Great Depression and prior to the Spanish Civil War share many similarities with those of Ukraine in the pre-war period following the annexation of Crimea and the onset of the conflict in the Donbas region. Both economies experienced growing budget deficits, currency depreciation, price instability, inflation and dependency on external debt or financial aid. Besides that, some non-economic similarities can also be tracked, such as notable political and social polarisation and regional separatism (Catalonia, Basque Country, Donbas). All of these factors make two cases more comparable which contributes to the further empirical analysis.

In contrast to the examples discussed above, certain countries maintained neutrality during major geopolitical crises and benefited from increased demand for their safe-haven markets. During the Second World War, the Swedish market remained operational, functioning as normally as possible with minimal or no restrictions, thereby offering investors a relatively stable environment (Waldenström & Frey, 2002). A similar dynamic was observed in the Swiss bond market, which remained active apart from a brief suspension during the period of German intervention in 1940 (Frey & Kucher, 2000).

As cited in the Waldenström and Frey (2002) Efficient Market Hypothesis states that asset prices at any given moment reflect all available information to actors, meaning that any movements in prices provide market participants with relevant information that forms their expectations about asset's performance, while Szkutnik and Wyłuda(2022) argue that period of the increased political and geopolitical uncertainty (or wars) actually makes markets highly inefficient. Empirically, from the analysis of the studies, the authors tend to agree with the latter view – for a long conflict, such as World War II, it's impossible to predict the end of the conflict by looking at the change in the yields. For example, had one looked at the yields of the bonds of different governments in the beginning of World War II, they would be under the impression of Germany and Austria winning the war, whereas, in reality, the situation changed quickly. This example leads the authors to believe that, although generally financial markets are forward-looking, in case of the uncertainty related to the war efforts, the financial markets actually tend to be reactive, rather than predictive.

Despite the aforementioned similarities in the direction of the changes in bond yields, – the decline in prices in the beginning of the conflict, and corresponding change in the yields reacting to the changes in the political uncertainty, in case of a long conflict, or recover for a short ones – worth noting that the magnitude of returns differ significantly between the conflicts, such as the reasonably small drop of -1% in case of the Israel-Hamas invasion 2008

(Kollias et al., 2010) or the -17% drop in the prices of the German bonds in the day of the outbreak of the World War II. Kollias et al. (2010) has suggested that the magnitude of the change in the value of the government bond index depends on some factors, such as duration and severity of the conflict, anticipation of the conflict, and external factors, such as the Global Financial Crisis of 2008 surrounding the Israeli invasion of Gaza. Martins (2024) has also suggested that this difference could be explained by the severity of the Hamas invasion of Israel being one of the cruellest in history.

Another insight that the authors were able to get from the previous literature is the transformation of the bond market of the countries under occupation. Loss of independence and government control accompanied by territorial and human losses may cause notable changes in the economic conditions experienced by the country, and may even lead to unwillingness of the invaders to repay debts issued by previous authorities. For instance, the armed coup that happened in Russia in 1917 caused repudiation of all sovereign debt by the Bolsheviks' government, which led to one of the biggest defaults in modern history (Ferguson, 1999). Across countries occupied during World War II, such as, for example, Norway, Denmark, France and Belgium, the following tendencies can be observed: when countries are being invaded, government bond prices experience sharp decline (e.g., -30% in Belgium; -28% in Denmark), but never face the full devaluation (e.g., at lowest point Danish bonds traded at 20% of par value) (Waldenström & Frey, 2002; Frey & Kucher, 2000). Throughout the occupation, the bond prices remain relatively flat until deoccupation opportunities occur (such as conflict dynamics developing not in favour of the invaders), when they face upward shifts. After the liberation, prices usually return to the pre-war level. As was mentioned in Subchapter 1.2. of this bachelor thesis, Szkutnik & Wyłuda(2022) theoretically support the hypothesis that bond prices of the country affected by war do not fall under the certain level (different from zero) at which they stabilise.

In the theoretical part of this bachelor thesis the authors outline how warfare impacts government bond markets through both macroeconomic and behavioural channels. Wars typically reduce GDP by lowering consumption, investment, and exports, while sharply increasing government spending. This worsens fiscal balances, forces higher debt issuance, and raises bond yields through increased risk premia and inflation expectations. Investor behaviour amplifies these effects through flight-to-safety, flight-to-liquidity, and flight-to-home dynamics, driving capital outflows and widening credit spreads in affected markets. Historical evidence from past conflicts shows patterns of yield spikes, market volatility, temporary loss of investor confidence, market following conflict’s course of action and

implications of government interventions. The chapter establishes a link between warfare, declining macroeconomic fundamentals, and increased bond market stress, providing a basis for the subsequent empirical analysis.

2. Transformation of Ukrainian government bond market during Russian-Ukrainian war – structural break analysis

2.1. Data and methodology

In this subchapter, firstly, the authors describe the datasets collected on Ukrainian government and corporate bonds, along with any data manipulations that were taken in order to prepare the data for the subsequent analysis. Then the authors outline the structural break analysis approach employed to identify significant changes in bond yields during the war period.

In order to empirically identify and map the transformations of the bond market in times of warfare to their potential causes it is needed to gather information providing the comprehensive overview of the Ukrainian bond market. Data retrieved for this research was obtained from two main sources: directly from a big financial market data vendor Cbonds – the authors sent a request to the company representative and were granted a limited access to the platform, allowing to screen and download financial data – and from the Ministry of Finance of Ukraine.

Worth noting that for the comparability of results whenever the Amounts (Table 4) were presented in the currency different to the US Dollar, the authors converted the Volumes to the US Dollar values based on the exchange rate at the time of the bond placement. The data for the exchange rates was retrieved from Google Finance API. For the better presentation of the results, the data was aggregated on a quarterly basis, unless otherwise stated, where Q1 represents the month from January to March; Q2 – April to June; Q3 – July to September; Q4 – October to December. For the comparison of the aggregate variables, such as yields or maturities, the authors used the volume-weighted average, which was computed based on the placement volume of the individual bond; using this approach the authors can ensure that the bonds with bigger volume have a relatively higher weight in the computation of the aggregate average values. The datasets used and their description are presented in the Table 4 below.

Table 4

Summary of the data sources used in the empirical research

Dataset	Period Covered	Number of Observations	Key Columns (Fields)	Source of Dataset

Government bond yield index (USD) – Index of Ukrainian government bonds denominated in US dollars (Eurobonds), daily yield-to-maturity (YTM).	04.01.2016–20.022025	Daily trading days (n = 2,384)	Index YTM (percentage) of USD-denominated government bonds (see Appendix A for index constituents), Date	Cbonds database
Government bond yield index (UAH) – Index of Ukrainian government bonds denominated in local currency (hryvnia), daily YTM.	03.012020–21.02.2025	Daily trading days (n = 1,341)	Index YTM (percentage) of UAH-denominated government bonds (see Appendix A for index constituents), Date	Cbonds database
Domestic government bond issuances (OVGZ) – Dataset of Ukrainian domestic government bonds (OVGZ) issued in local auctions.	Full history up to 2024 (exact start not stated)	Per issuance (n = 1,070)	Placement type, ISIN, Placement date, Maturity date, Weighted average yield (coupon rate), Currency, Realized issuance volume	Ministry of Finance (Ukraine)
OVGZ holdings by investor type – Holdings of domestic government bonds by investor category over time.	01.01.2020–31.12.2024	Monthly (n = 60) aggregated to quarterly	Outstanding amount of OVGZ held by: Banks, Foreign Institutions, Legal Entities, Private Investors, National Bank of Ukraine (NBU)	Ministry of Finance (Ukraine)

Source: compiled by the authors.

Worth noting that preliminary inspection of the datasets containing the yields of the USD and UAH Government Bond Indices revealed 16 missing values for USD bonds and 11 missing values for UAH bonds. Since missing points were not occurring systematically, linear interpolation was used to fill them. This choice ensures smooth daily bond yields movement. Additionally, the authors formatted all the data to appropriate types and generated the time index in order to make the further analysis possible and simple.

All data were processed and analysed using appropriate software tools: Python (in a Jupyter Notebook environment) with standard data libraries (the programming code can be found in Appendix B); and in the statistical software – Stata (the programming code can be found in Appendix C).

In order to achieve the aim of this bachelor thesis, the authors decided to conduct a structural break analysis that will be applied for determining significant changes in bond yields during the war period. This type of methodology was successfully used by Frey and

Kucher (2000) and Waldenström and Frey (2002), it implies econometric techniques to detect fundamental structural breaks in data and further analyse their significance and impact. After that, the authors will try to interpret these breaks with specific events that took place in Ukraine, complementing authors' assumptions with analytically observed transformations of Ukrainian bond market supported by data during the war. This approach will deepen the understanding of the Ukrainian bond market's behaviour and transformation during a relatively long period of time. Structural breaks' interpretation will complement the insights obtained from the theoretical part by widening the view of the market adjustments over time and contribute to reliability of outcomes.

In order to capture strong fundamental shifts in data that can be interpreted by real-world economic, military or political events, the data was divided into several samples. The reasons behind the choice of samples' sizes can be explained by authors' need to identify and estimate potential breaks on a different scale (consistent detection of a break under different model parameters and sample sizes adds to the fundamental meaning of the underlying event). Besides, except in the case of War-only samples, the authors try to maintain balance between the amount of data before and after the war outbreak, providing the algorithm with a certain baseline or "normal" behaviour of bond yields.

After preparing the data samples, as described above, the Bai-Perron (1998, 2003) multiple-break model was employed as implemented in Stata's package by Ditzen et. al. (2025) (*xtbreak* command). This approach allows testing for one or more breakpoints, where a "break" implies a change in the underlying data-generating process (e.g., mean level, slope) of the yield series. The method accommodates an unknown number of breaks at unknown dates and uses both a global test (UD_{max}) to reject "no breaks," as well as sequential tests (e.g., F(1|0), F(2|1), etc.) to determine how many breaks are supported by the data. This method also uses a trimming parameter (ε), which sets the minimum proportion of observations each segment must contain. (Andrews, 1993; Bai & Perron, 2003) For instance, 10% trimming means that no break can occur within 10% of the start or end of the series, and each segment after break must also contain at least 10% of the sample. Lower trimming (5%) allows more breaks – including very short shifts, while higher trimming (15%) allows fewer, broader regimes. In this research the authors run sequential tests with 15% 10% and 5% trimming for each sample. The division of the samples is presented in the Table 5 below:

Table 5

Summary of the data division into separate samples

Sample Name	Date Range (USD index)	Number of Observations (USD index)	Date Range (UAH index)	Number of Observations (UAH index)	Rationale
Full sample	04.01.2016 – 20.02.2025	2,384	03.01.2020 – 21.02.2025	1,341	Entire available period (multi-year), providing long-run context including pre-war and war periods.
Subsample M	01.07.2020 – 20.02.2025	1,212	08.10.2020 – 21.02.2025	1,142	Mid-range window starting around 1.5 years before the invasion, to balance pre- and post-war data (establishing a baseline of normal conditions before the war and excluding strong irrelevant shifts).
Subsample S	01.03.2021 – 20.02.2025	1,039	N/A (not used for UAH)	N/A	Shorter window closer to the war onset, providing finer focus around the invasion period (used only for USD index due to shorter UAH series availability).
War-period only	22.02.2022 – 20.02.2025	783	24.02.2022 – 20.02.2025	782	War-specific window covering from just before or at the outbreak of the large-scale invasion in Feb 2022 through three years of conflict. Captures only wartime dynamics without pre-war data.

Source: compiled by the authors.

Hypotheses tested for UD_{max}:

H_0: No structural breaks in data;

H_1: There is(are) s breaks ($1 <= s <= s_{max}$).

Hypotheses tested for sequential test:

H_0: There is(are) s breaks;

H_1: There is(are) s+1 breaks ($1 <= s <= s_{max}$) (tested iteratively until no further significant breaks occur or until the maximum number of breaks supported by data is reached).

Where:

s – number of breaks

s_{max} – maximum number of breaks allowed by chosen trimming parameter

After sequential tests (UD_{max} included in sequential test) the authors conduct a "fixed-break" approach, specifying the exact number of breaks depending on the results of sequential tests. For example, when sequential tests with 5% trimming shows 19 statistically significant breaks (which is a maximum possible number of breaks supported by data), the number of breaks was limited to 5 in order to give the algorithm an opportunity and flexibility to capture the most interpretable breakpoints rather than every small fluctuation. In other words, depending on the nature of data the authors adjust trimming and number of breaks in a way that allows the authors to capture the most significant breaks and minimises the chance of missing important shifts. In this research the authors consider 10% trimming and 5 breaks an optimal setting to achieve this goal, based on earlier sequential test outcomes. This choice ensures practical balance between avoiding overfitting (producing evenly spaced breaks unrelated to any recognizable economic or political developments and thus capturing noise rather than fundamental shifts) and providing enough flexibility to the model to capture the most significant structural shifts in bond yields. Hypotheses for multiple breaks test with fixed number of breaks:

H_0: No structural breaks in data;

H_1: There is(are) *s* structural breaks (where ***s*** – number of breaks specified in advance).

It is also important to mention that each of the tests additionally includes so-called "*vce(hac)*" (variance-covariance estimator) option, which is essentially a more robust approach that accounts for heteroskedasticity and autocorrelation.

General mathematical grounding for Bai-Perron (1998, 2003) multiple-break regression model is expressed by the following equation:

(1)
$$y_t = x_t'\beta + z_t'\delta_j + u_t$$
$$t = T_{j-1} + 1, \dots, T_j, j = 1, \dots, m + 1$$

Where:

x_t – regressors whose coefficients β stay constant across regimes

z_t – regressors whose coefficients δ_j are allowed to change at each break

u_t – error term (possibly serially correlated / heteroskedastic)

$\{T_1,\dots,T_m\}$ – *unknown break dates*

In this study's yield-only application the authors do not include any additional explanatory variables being interested purely in shifts in the unconditional mean of bond yield series. Therefore, the model simplifies to the following special case:

(2) $$y_t = \mu_j + u_t$$
$$t = T_{j-1} + 1, \dots, T_j, j = 1, \dots, m + 1$$

Where:

μ_j – *the regime-specific mean*

u_t – *zero-mean error that may be heteroskedastic and serially correlated*

A trimming parameter ε (in our case $0{,}05 \leq \varepsilon \leq 0{,}15$ with a step of 0,05) enforces:

(3) $$T_j - T_{j-1} \geq \varepsilon T$$

Which means that every segment between breaks contains $\varepsilon \times 100\%$ of the observations.

The algorithm works by searching for the best possible placement of breakpoints, where "best" means the total error (sum of squared residuals) is minimized in each segment. To do this efficiently, the algorithm uses dynamic programming. This makes the method suitable for applications with big datasets as in the case of this research. Full description of the model as well as all raw data used in the research can be found in the Appendix D.

Once the breakpoints are identified for each sample, the final step is to interpret these breaks in the context of the Russian-Ukrainian war. Each break date corresponds to a very narrow point in time where the structure of bond yields shifted. The authors then compare these break dates against the timeline of major economic, political, or military events in Ukraine. The goal is to link each significant structural break to potential real-world catalysts, such as the outbreak of war, policy announcements, sudden changes in investor sentiment, or escalations in conflict. The authors pay particular attention to breaks that are consistently detected across different samples and trimming settings, as these signal especially robust events. These interpretations are supported by evidence from news, financial reports and governmental institutions as well as by the theoretical frameworks discussed in the literature review.

2.2. Results of analysis

In the empirical part of this bachelor thesis, the authors are going to provide a short overview of the Ukrainian bond market before the war and then present the results of the structural break analysis, further complementing them with authors' interpretation of the

results that takes into account findings from the theoretical chapter as well as real economic and geopolitical context.

During the past two decades Ukrainian bond market started being only around 15% of the country's GDP, however, was growing fast mainly driven by the additional issuance of the government debt. Prior to Russia's invasion of Ukraine in February 2022, the Ukrainian government had primarily relied on the international bond market as a main source of borrowing via so-called Eurobonds. The corresponding volumes of government and corporate debt are presented on Figure 1 below. From 2015 to 2021, the share of domestic bonds in the total stock of marketable securities saw a steady increase, rising from around 33% to 50%. This growth was largely fuelled by the issuance of sovereign bonds. A key factor in this development was the implementation of favourable tax policies, which made investing in domestic bonds more attractive. This led to significant foreign capital inflows into the government bond market. (Haas, Pivovarsky, 2022) Notably, it can be observed that the corporate bonds, although started equally and were initially growing faster than government debt, were quickly reversed following the 2007-2008 crisis.

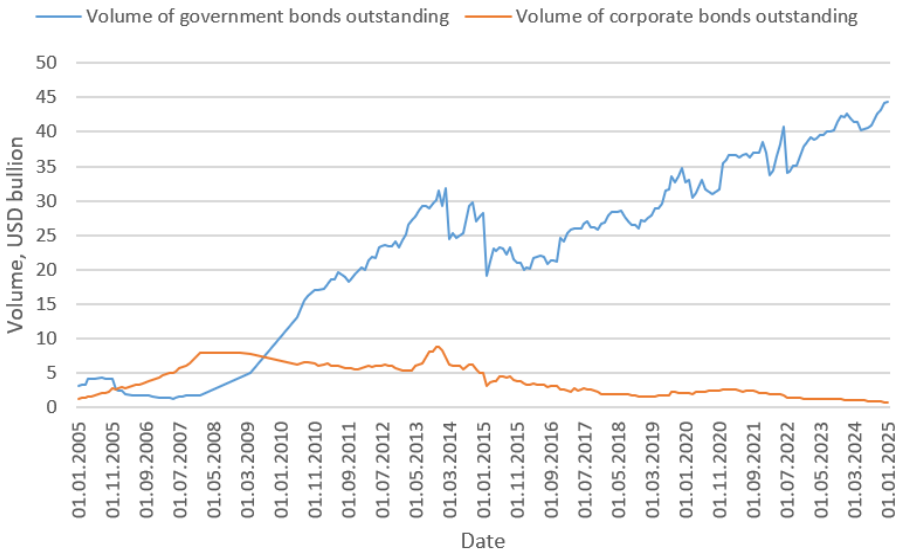


Figure 1. Corporate and government bonds outstanding volume, USD billion
Source: compiled by the authors

Let the authors proceed to discussion of the outputs of the structural break analysis on the yields of USD and UAH denominated government bond indices in order to identify fundamental structural shifts in yields data and later map them to the real-world events that could have caused them.

The Table 6 below shows the results of testing each sample for no breaks against some breaks (UD_{max}).

Table 6

Summary of UD_{max} tests for no breaks, different trimming levels (full sample, USD)

Sample	Trimming	UD_{max}	1% CV	5% CV	Conclusion
Full sample, USD	15%	418.41	12.37	8.88	Reject H0
	10%	494.47	13.07	9.52	Reject H0
	5%	1144.39	13.74	10.17	Reject H0
Subsample M, USD	15%	323.85	12.37	8.88	Reject H0
	10%	1007.23	13.07	9.52	Reject H0
	5%	1795.98	13.74	10.17	Reject H0
Subsample S, USD	15%	386.58	12.37	8.88	Reject H0
	10%	1171.6	13.07	9.52	Reject H0
	5%	3174.54	13.74	10.17	Reject H0
Full sample, UAH	15%	112.05	12.37	8.88	Reject H0
	10%	116.54	13.07	9.52	Reject H0
	5%	386.99	13.74	10.17	Reject H0
Subsample M, UAH	15%	108.35	12.37	8.88	Reject H0
	10%	150.45	13.07	9.52	Reject H0
	5%	517.63	13.74	10.17	Reject H0
War-only sample, USD	15%	520.18	12.37	8.88	Reject H0
	10%	800.63	13.07	9.52	Reject H0
	5%	1015.40	13.74	10.17	Reject H0
War-only sample, UAH	15%	8.72	12.37	8.88	Reject H0 (10% CV)
	10%	20.48	13.07	9.52	Reject H0
	5%	78.85	13.74	10.17	RejectH0

Source: compiled by the authors.

From this table it can be seen that each sample with different parameters provides strong evidence of fundamental structural shifts present in data. The only mild evidence presented concerns UAH denominated bond index when testing the period that isolates the war (from 24.02.2022 – 20.02.2025). It can be explained by the nature of the sample itself containing less observations and high volatility without a clear data baseline. Despite this fact, the model can still provide some insights when taking into account other conducted tests and real context.

In order to summarize the key findings of empirical analyses, Table 7 below presents the most interpretable of detected breaks that consistently occur across different structural break models and their corresponding dates. Additionally, the authors include in the table a short description of the potential causes that could affect fundamental shifts in bond yields, relying on real economic, political or geopolitical events that took place around indicated periods of time.

Table 7

Major structural breaks captured across different tests' results

USD government bond index	UAH government bond index

Break points	Potential causes	Break points	Potential causes
18.02.2022 – 23.02.2022	● War outbreak	02.03.2022	● War outbreak
20.06.2023 – 27.06.2023	● Wagner mutiny in Russia ● EU support package ● World Bank support ● Fed hawkish stance	22.11.2022	● Heavily damaged energy infrastructure/nationwide blackouts ● Stringent monetary policy measures
11.07.2023 – 14.07.2023	● NATO summit in Vilnius ● Grain deal tensions	10.03.2023	● NBU policies ● Slowed inflation ● IMF support
04.09.2024 – 06.09.2024	● Debt restructuring	02.09.2024 – 10.09.2024 (large CI)	● Stable inflation y.o.y. ● Interest rate cuts ● Debt restructuring ● IMF support

Source: compiled by the authors

The Bai-Perron's structural break analysis conducted on UAH and USD denominated Ukrainian government bond indices shows both overlapping and distinct results reflecting market behaviour during the warfare. While both indices demonstrate sensitivity to major economic and geopolitical events, the timing and magnitude of the detected breaks differ between indices depending on the nature of the underlying events. USD-denominated bonds being held mostly by foreign investors demonstrate higher exposure to global financial conditions and geopolitical shocks. Investors' behaviour in this case might align with some of the effects discussed in the theoretical part, such as flight-to-safety and flight-to-home effects as mentioned by Beber et. al. (2009) and Agoraki (2024); Ukrainian sovereign bonds after the invasion demonstrated an extremely high chance of default, which could lead to rapid capital outflows from the emerging frontier markets. UAH-denominated bonds seem to be more influenced by internal monetary policy, inflation expectations and regulations, making it possible to draw a parallel with the historical case of Spain, highlighted in the literature overview – Subchapter 1.3. (Baltilossi, 2011). Figure 2 visually demonstrates the dynamics of YTM in the USD and UAH-denominated indices with indication of the strongest structural breaks.

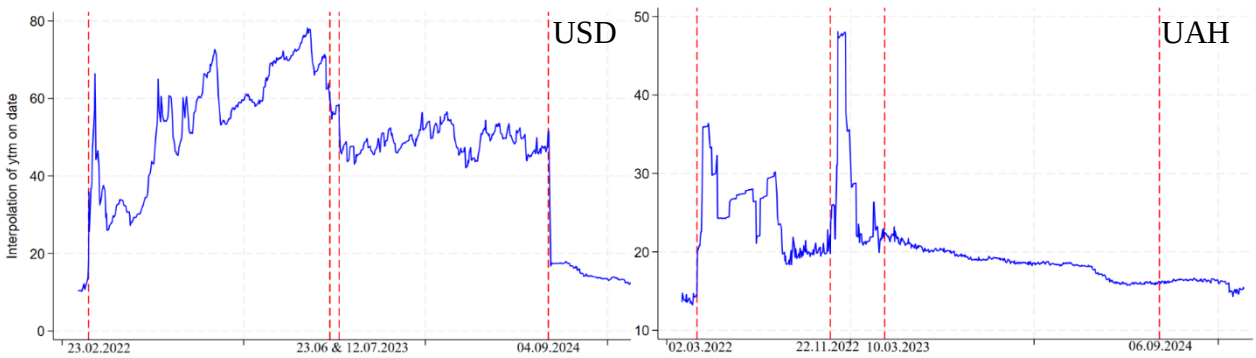


Figure 2. Structural break tests composite output: YTM plotted over time, USD and UAH-denominated indices

Note: Structural breaks are indicated with red vertical dash lines

Source: compiled by the authors.

It is important to mention that in this research the authors do not claim any causality effects between real events that took place and shifts in bond yields. The purely data-driven nature of the chosen testing method provides particular dates out of context, so the following interpretation is based on theoretical frameworks discussed in the first chapter as well as on authors' assumptions about real-world events and their potential causes.

2.3. Discussions of results

In this subchapter, the authors focus on the detailed interpretation of the structural breaks in the yields of the Ukrainian government bond indices and mapping them to the real-world events, relying on the theoretical frameworks discussed in the Chapter 1 of this bachelor thesis as well as economic and geopolitical context surrounding the break dates.

The first structural break captured on **18-23 February 2022 (USD) and 2 March 2022 (UAH)** may refer to the beginning of full-scale war conflict between Russia and Ukraine reflecting sharp decline in investor confidence. As a result, one can witness an immediate reaction of yields rising drastically from 10-13% in the mid-February to 66% during the first two weeks after invasion for USD-denominated bonds and from 13-14% to 36% in almost the same time period for UAH-denominated bonds. Prior to Russia's invasion, the Ukrainian government had primarily relied on the international bond market as a main source of borrowing via so-called Eurobonds. Immediately after the start of the war Ukraine imposed martial law and strict capital controls, including a moratorium on nearly all cross-border currency transactions and repatriation of funds (Haas, Pivovarsky, 2022) and has been cut off from access to international bond markets. Ukrainian foreign debt was rated in selected default by major credit agencies (Satija, B., & Nair, A, 2022). The response of the bond market and the aforementioned credit agencies' actions align with authors' discussions

in the Subchapter 1.1. Warfare leads to sharp decline in the overall economic activity with only the growing aspect – government expenditures driven by military spending.

This aligns with the bond markets' response to the outbreaks of military conflicts documented in studies by Fergusson (1999), Frey and Kucher (2000), Frey and Waldenström (2002), where in the Subchapter 1.3 the authors have highlighted the same pattern. Yield of the USD bond index spiked right after foreign investors reassessed creditworthiness of Ukrainian securities and faced drastic increase in default risk, which again suggests flight-to-quality effects. UAH-denominated bonds responded with a slight delay, likely, due to immediate capital control and emergency monetary measures initiated by the government as an attempt to quickly stabilise the market.

Structural break on **20-27 June 2023 (USD)** followed by a sharp decline in bond yields may correspond to a combination of important events that took place at that period of time. One of the potential reasons could be Wagner Group's armed mutiny in Russia (23-24 June), which contributed to heightened uncertainty in the whole region (Kirby, 2023). Despite the fact that the rebellion was short it quickly attracted international attention and raised questions regarding the stability of the Russian regime. This reasoning may be supported by the findings from the analysis of the previous empirical studies (Subchapter 1.3) where the authors have demonstrated that bond prices (in this case – yields) largely followed the changes in the warfare landscape during WWII (Frey and Kucher, 2000). Another highly important factor to consider concerns the Federal Reserve maintaining federal funds rates at 5,25% following a series of rate increases aimed at fighting inflation (Smialek, 2023). Increases in U.S. interest rates can lead to higher borrowing costs for USD-denominated Ukrainian bonds, causing capital outflows from European markets, increasing bond yields in emerging and developed economies (Arteta et al., 2022). This is also supported by the findings from the Subchapter 1.2 of this research, where the authors discuss behavioural tendencies among investors – particularly, flight-to-safety/liquidity effects. Additionally, financial support from the EU and World Bank to Ukraine could have some effect on yields, increasing investor confidence and the economy's financial stability (World Bank, 2023; European Commission, 2023). All of these factors could play a role in the dynamics that are witnessed in USD bond yields.

Another structural break took place on **11-14 July 2023 (USD).** It is worth mentioning that structural break at this period of time may be somehow correlated with previous break in the late June 2023 due to close location in time, however several independent tests captured this shift with narrow confidence intervals. The behaviour of

yields around this time segment can be characterised as slightly volatile with rising tendencies after the plunge from nearly 80% to 40-46%. This breakpoint corresponds to the NATO summit that took place in Vilnius, where a substantial military aid package was granted to Ukraine from Germany and Norway (NATO, 2023). However, no guarantees were given to Ukraine regarding membership, which could amplify uncertainty on the market. Another important factor that might have an impact on yields is the "grain deal". The agricultural sector is a critical component of Ukraine's economy, amounting to about 10% of the country's GDP before the invasion (State Statistics Service of Ukraine, 2023). Hence, this sector represents a significant portion of GDP, as discussed in the Subchapter 1.1, rapid changes in the sector can lead to inverse effects in the bond yields.

Most of the agricultural goods in Ukraine were sold abroad with a share of agricultural exports amounting to about 40% of Ukraine's total exports in 2021 (National Institute for Strategic Studies, 2022). Therefore, Russia's withdrawal from the Black Sea Grain Initiative (Nichols et al., 2023) could raise serious concerns about economic stability of the country, which aligns with findings of Mielcarzl et al. (2023), as discussed in the subchapter 1.1: disruptions in supply chains and restrictions in trade being the common factors during war conflicts, can provoke heightened uncertainty on the financial markets. Longer-lasting effects from the previous break in June (e.g., Fed rates) could also be considered a factor of influence.

The structural break on **4-6 September 2024 (USD)** most probably refers to a strong fundamental shift in Ukraine's USD bond yields that plunged immediately almost to pre-war level. This shift corresponds to the country's successful agreement on external debt restructuring of about 20,5 billion of international debt with 37% principal "haircut" and reduced interest payments for the following years (Fitch Ratings, 2024). This procedure was conducted in coordination with the IMF and supported by G7 creditors, demonstrating common sentiment regarding Ukraine's financial solvency and recovery (White & Case LLP, 2024). Re-evaluation of default-risk and long-term debt sustainability led to sharp drop in yields. Paper by Jeanneret (2015) that the authors mentioned in the theoretical part when discussing sovereign credit spreads provides a framework of credit risk that matches the situation with this structural break, showing that sovereign bond spreads react to changes in the government's ability and willingness to repay debt. Restructuring can shift the point at which investors expect a default to happen, especially when supported by credible institutions like the IMF. In the case of Ukraine, the coordinated nature of the debt restructuring could contribute to market confidence.

The structural break on **22 November 2022 (UAH)** can be characterised by a sharp spike with peak values of around 48% from being relatively stable around 20-30%. This shift occurred right after a period of intensified attacks on Ukraine's energy infrastructure leading to nationwide blackouts (Landry, 2022; BBC News, 2022). However, beyond geopolitical shocks, domestic monetary policy could also play a significant role in yields' behaviour at this period of time. Back in June 2022, the NBU increased interest rate from 10 per cent to 25 per cent, as a way to cool the economy and prevent the spike of inflation (NBU, 2022). Also, "the NBU has tied the rate of remuneration of bank liquidity (the so-called deposit certificates) at minus two per cent points of the policy rate, so that banks could get risk-free 23 per cent on their liquidity". (Giusto, H, 2024). This made banks less interested in lending to businesses or buying government bonds. This policy created an unusual situation in the bond market. The Ministry of Finance refused to raise interest rates on UAH bonds, so during the auction on 22 November 2022, it rejected most of the bids (Kotovych, 2022). This could potentially catalyse the sharp increase in yields reflecting the mismatch between government, investors and banks. The Figure 3 below shows the weighted average annual coupon yields in the UAH denominated OVGZ.

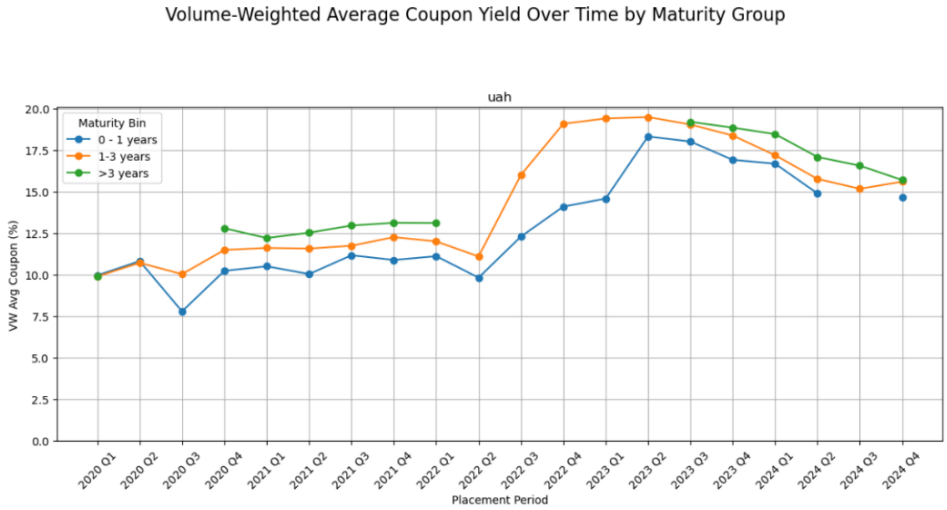


Figure 3. Volume Weighted Average Coupon Yield of the UAH OVGZ

Source: compiled by the authors based on Ministry of Finance data.

As can be seen, in 2022, the coupon yields were very small compared to the rate the banks could get on the liquidity, which led to the commercial banks essentially not buying the domestic bonds.

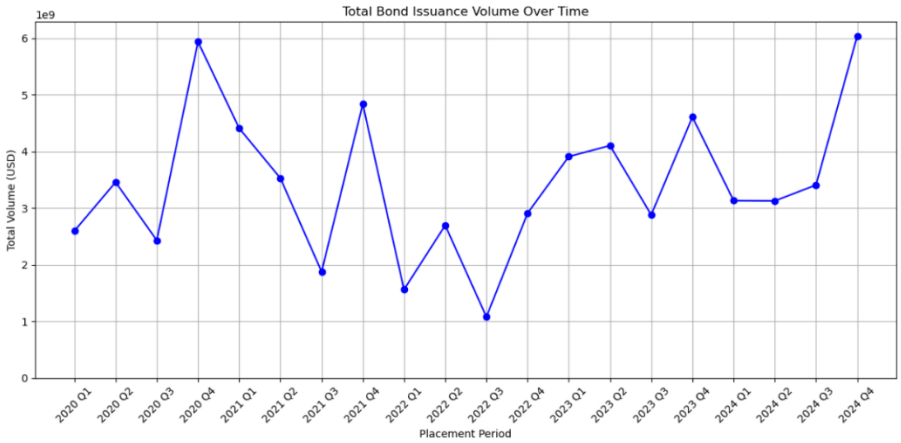
Since domestic bonds were offered at the below-market rates, the demand for the bonds was very small, and on the Figure 4 below one can see the total amount of the issued OVGZ in the billions of USD. A notable pattern can be clearly observed, where immediately

after the start of the invasion the total volume has dipped, and remained flat throughout the whole of 2022.

Figure 4. Total OVGZ Issuance in billions of dollars

Source: compiled by the authors based on Ministry of Finance data.

Interesting observation is that the number of the bonds issued has not changed, and



the decline was primarily attributable to the decline in the average bond issuance; it can be seen on the graphs showing the number of bonds issued over the quarter, and the average bond issuance amount over the quarter in the Appendices E and F. Figure 5 below presents the breakdown of the Bond Placement Volume over time by currency and the graph in the Appendix G presents the number of bonds of different currencies issued over the period of time. Worth noting that the decline in the bond issuance was primarily attributed to the decline in the UAH-denominated bonds. The USD and EUR denominated held stable over the whole period of the war and before it.

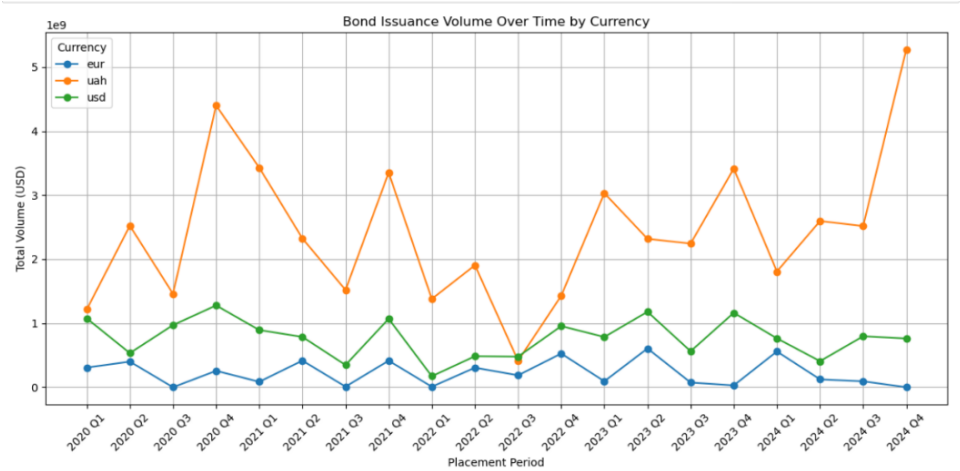


Figure 5. Issuance of the OVGZ over time broken down by currency of issuance, billions of USD

Source: compiled by the authors based on Ministry of Finance data.

Similarly, with lack of demand for the domestic bonds in the beginning of the war, the Ukrainian Budget Deficit was primarily funded through the National Bank of Ukraine buying the domestic bonds from the Ministry of Finance and putting them onto its own Balance Sheet. Figure 6 below illustrates this phenomenon. As one can see in the period of 2022, the ownership of OVGZ by Banks, Foreign Institutions, Legal Entities and Private Investors has declined significantly because of the reasons discussed above, while the NBU took their place.

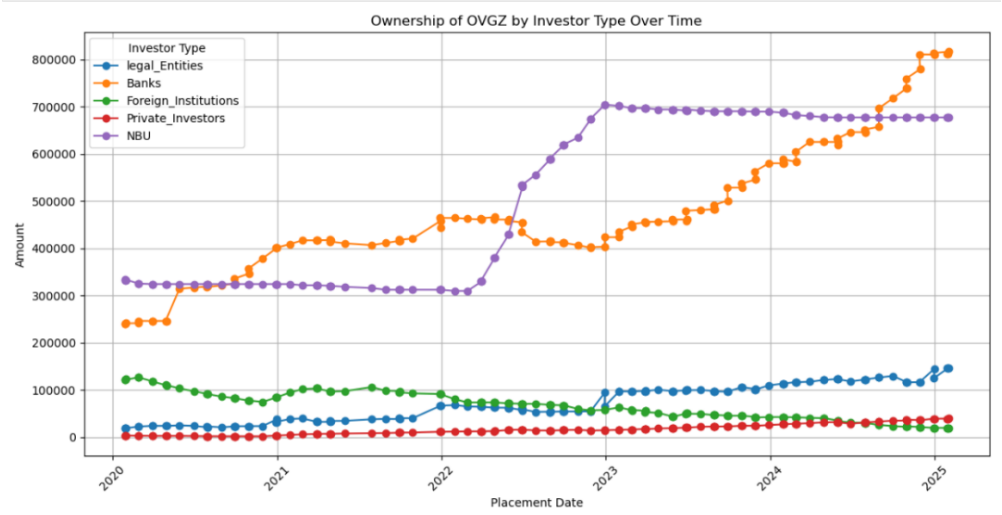


Figure 6. Amount of the OVGZ owned broken down by the Investor Type
Source: compiled by the authors based on Cbonds data.

Finally, looking at the maturities in Figure 7, an interesting trend can be observed. In the first phase, when the Ministry of Finance had a hard time selling the domestic bonds the maturities have been declining with average maturity getting as low as to below 1 year for all the UAH, USD and EUR denominated bonds in 2022. However, from 2023 onwards with the increase in the coupon yields, and when the economy of Ukraine has omitted initial shocks, the maturity started to increase, particularly in the UAH denominated bonds getting to more than two years on average.

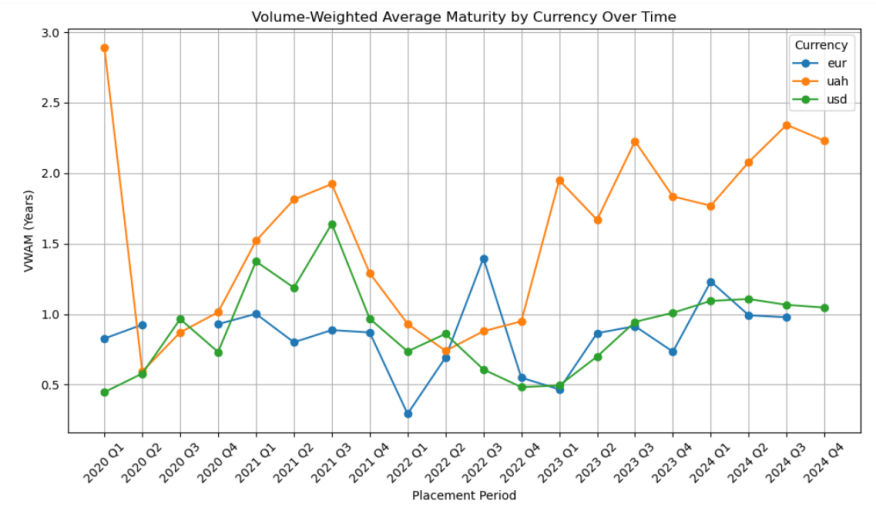


Figure 7. The volume-weighted average maturity of the placed OVGZ broken down by the currency.

Source: compiled by the authors based on Ministry of Finance data.

Another structural break occurred on **10 March 2023 (UAH).** In the end of 2022 and onwards, the Ministry of Finance had to raise yields to the market rates to attract investors (both commercial banks and legal entities) (Giusto, H, 2024). As can be seen on the previously introduced Figure 6, the yields on the UAH-denominated bonds rose sharply from Q4 2022 reaching the level of 19-20%. This led to domestic banks tapping back into the domestic bond market and helping to finance the war efforts. Strong liquidity in the banking sector (a side effect of the NBU support and the lack of business lending due to the high rates on the deposit certificates) enabled banks to quickly buy large quantities of the OVGZ.

The increased demand for the Ukrainian bonds may have happened at the period of the detected break, resulting in UAH bond yields demonstrating gradual decrease. Among additional factors that could influence this dynamic the authors can highlight National Bank of Ukraine (NBU) maintaining key policy rate unchanged, while introducing three-month certificates of deposit with a fixed rate equal to the key policy rate, as well as cut interest rates on overnight certificates of deposit to 20.00% (FocusEconomics, 2023). This decision could support bond market confidence and demand by stabilising rates and reducing excess money supply (potentially redirecting banks' extra cash to government bonds, which would lower yields for short-term bonds and at the same time boosting demand for long-term government bonds).

On top of that, inflation update was presented by NBU notifying about slowing consumer inflation – 21,3% y. o. y. from 24,9% y. o. y. in previous month, which fosters increased bondholders' confidence even more (National Bank of Ukraine, 2023). Being one

of the biggest concerns for bondholders, inflation directly impacts the real value of fixed income payments from securities, as it was mentioned in the Subchapter 1.1. Decrease in the inflation can show relative increase in the purchasing power of the future bond payments, causing yields to fall (Abbas & Lan, 2020). Additionally, the IMF approved a program that includes provision of 15,6 billion USD over a 4-year period, acting as a catalyst for international financial aid. At the same time, disinflation is helping to drive up real interest rates, making UAH-denominated assets, including government bonds, more attractive (Burban et. al., 2024).

The last structural break in UAH-denominated bonds occurs on **2-10 September 2024 (UAH),** just after the USD bond index break that the authors connected to major debt restructuring. It is important to emphasise that the exact point in time when this particular shift took place is hard to precisely identify due to large confidence intervals, which could mean that the model corresponds to change in rate of yields' decline or shift in market volatility. Despite the fact that no sharp change is visible on the yield graph (Figure 2), the structural break in early September 2024 can be associated with a series of important macroeconomic events, such as decreasing inflation, the NBU consecutively cutting rates to 13,5% in April and 13% in June, and the successful restructuring of external debt (National Bank of Ukraine, 2024; Rosario & Krasnolutska 2024). Besides, on September 10, the IMF and Ukrainian authorities reached an agreement that grants Ukraine access to about 1 billion USD (International Monetary Fund, 2024). These factors likely contributed to a gradual but persistent decline in yields, marking a shift in investor expectations and the risk profile of UAH-denominated domestic bonds. The break may thus reflect a transition to a more stable financial environment, rather than a particular discrete event.

Over the whole period of war, Ukrainian domestic bond market has undergone another significant transformation – rise of retail lending to the government. This phenomenon was previously discussed in the Subchapter 1.2, where Szkutnik and Wyluda (2022) argued that after the initial conflict outbreak patriotic investors often buy into the government bonds, accepting lower returns in favour of supporting their country. Before 2022, direct purchases of government bonds by individuals or non-financial companies were rare due to the high barriers and as could be seen on the Figure 6 (Giusto, H, 2024) During the war, when effectively Ukraine was unable to borrow internationally, as it used to do, the Ministry of Finance of Ukraine introduced a new way to fund its budget – war bonds. Those bonds were marketed to the citizens of the country and were presented as a way to invest in the Ukrainian future and symbolically were named after the cities in the Russian occupation.

Additionally, the Ministry of Finance has made it easier for every citizen to access the bonds, since they were sold in small denominations (1000 UAH or around 30 USD), and were distributed through the commercial banks and the e-governance app Diia, which is available to download to every citizen. (Hrazhdan, O, 2024) Additionally, the war bonds were tax exempt, which presented a great alternative to the traditional bank deposits, and, in sight of the currency and capital controls, were presenting attractive returns against inflation and currency devaluation. As shown in Figure 6, the ownership of the OVGZ by Legal Entities has increased nearly sixfold. The actions of the Ukrainians in response to the war is similar to the attack of Hamas on Israel in 2023. As covered in the Subchapter 1.2., Israeli diaspora decided to lower the yields in order to support their country, while the commercial market reacted oppositely by increasing yields, as did Ukrainian publicly traded indices (Bradley et. al., 2024; Martins, 2024). Although even after such a boom the Legal Entities do not represent a massive share of the Total Ownership (dominated by the NBU and Commercial Banks), their participation has helped a lot for the Ukrainian Government to fund the war efforts. The actions of the foreign holders, on the other hand, presented the flight-to-home effect, previously described in the theoretical part. While they foreign holders have been major owners of the Ukrainian bonds before the war. Although the capital controls introduced by NBU in 2022, has slowed down the process of fleeing of the international capital out of Ukrainian Bond Market, it has not stopped the decline in ownership by the Foreign Holders, with their ownership in the end of 2024 being close to 1%.

The above-mentioned holder base realignment and the increased coupon yields has led to the significant improvement in the Ukrainian domestic bond market with the average bond issuance size and the overall placement volume increasing. Worth noting that the main growth of demand was for the UAH-denominated domestic bonds, and while the Eurobonds and the EUR or USD denominated bonds were in standstill, the UAH denominated bonds become a significant portion of the Ukrainian bond portfolio, as could be seen in the Figure 7.

Conclusion

The analysis carried out in this bachelor's thesis demonstrates that warfare has a significant influence on the government bond market. From a theoretical perspective, the thesis highlighted that warfare can disrupt macroeconomic stability and financial market functioning. Conflicts tend to drive interest rates and risk premia sharply higher, create inflationary pressures, and increase the sovereign default risk due to escalating fiscal burdens and economic damage. Governments facing war often take extraordinary measures (such as capital controls or emergency financing) to stabilise their markets. These factors drive up

bond yields and widen credit spreads in affected markets. At the same time, investor behaviour in such crises follows some patterns: extreme uncertainty triggers flight-to-quality and flight-to-liquidity dynamics, where investors reallocate capital from the markets affected by conflict to safer and more liquid assets. International investors typically withdraw funds (a "flight-to-home" effect), while domestic investors may become the primary source of funding, sometimes motivated by patriotism. Historical cases of war and crisis – from the World War II bond market disruptions to more localized conflicts – exhibit similar tendencies of surging yields, liquidity strains, and heavy government intervention.

From an empirical perspective, the structural break tests on Ukrainian government bond yields (conducted separately for UAH and USD denominated bonds) identified several critical shifts corresponding to major phases of the war. The lifecycle of the Ukrainian government bond market can be broadly divided into two periods: immediately after the war (2022 – 2023) – an initial crisis – and after 2023 onwards – a period of partial recovery and further improvement of credit conditions.

At the outbreak of the full-scale war in late February 2022 bond yields spiked. As the conflict progressed, the bond market went through further structural changes that reflect the changing state of the frontline and policy environment. Mid-2023 saw a significant break in yield trends: after more than a year of elevated yields, Ukrainian bond yields began to decline around June-July 2023. This coincided with a series of notable events, including shifts on the frontline and continued international financial support for Ukraine. A further transformation occurred in late 2024, bond yields fell back towards pre-war level when Ukraine reached a major external debt restructuring agreement with international creditors (with substantial debt relief and restructured payment terms). The successful restructuring effectively reduced default risk despite the ongoing conflict.

Beyond the movements in yields, the war caused changes in the structure of bondholders in Ukraine: foreign investors, who were significant holders of Ukrainian government bonds before the invasion, almost entirely exited the market after the war outbreak. Domestic institutions (such as local banks and the central bank) and domestic investors filled this gap by increasing their share of the lending to the Ukrainian government.

Authors also want to highlight some possible areas for the further research, taking into account the study's limitations. One clear direction is to examine the long-term post-conflict bond market transformations. Since the conflict was ongoing during the research, the recovery process remains outside the scope of this thesis. Future research could study how quickly (or whether) bond yields switch to pre-war norms, how investor confidence rebuilds,

and what permanent changes result from the wartime experience. Another important extension would be to broaden the scope beyond the government bond market. This study focused on sovereign bonds, but the transformation of the other financial markets may also be researched – for example, equity markets, corporate debt, or currency markets in Ukraine and neighbouring economies. Comparative studies across different asset classes could reveal whether those markets behaved differently under conflict conditions. Similarly, applying the analytical framework of this thesis to other conflict contexts would test the generalisability of the findings: researchers could investigate if bond markets in other war-affected countries behave similarly. Lastly, future studies might incorporate alternative methodologies – for instance, conducting interviews with market participants – to gain micro-level insight into how information and expectations spread during wartime financial crises.

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APPENDICES

Appendix A.

International Securities' Identification Numbers (ISINs) of constituents of USD and UAH denominated bond indices

#	USD bond index ISINs	UAH bond index ISINs
1	XS2895056872	UA4000207518
2	XS2895056955	UA4000218531
3	XS2895057177	UA4000227193
4	XS2895057334	UA4000227193
5	XS2895055981	UA4000227201
6	XS2895056013	UA4000227490
7	XS2895056369	UA4000228043
8	XS2895056526	UA4000228381
9		UA4000228811
10		UA4000229116
11		UA4000230270
12		UA4000231195
13		UA4000232177
14		UA4000232607
15		UA4000232615
16		UA4000232896
17		UA4000232912
18		UA4000233613

Source: compiled by the authors.

Appendix B.

Programming Python code used for the transformation and analysis of the OVGZ data

```
import pandas as pd
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
import re
from scipy import stats as st
from datetime import date
from ydata_profiling import ProfileReport

def get_four_month_bin(year: str, month: str) -> str:
    """Returns a string label for the 4-month period bin."""
    month = int(month)
    if month in [1, 2, 3]:
        return f"{year} Q1"
    elif month in [4, 5, 6]:
        return f"{year} Q2"
    elif month in [7,8,9]:
        return f"{year} Q3"
    elif month in [9, 10, 11, 12]:
        return f"{year} Q4"
    else:
        return "Unknown"

def classify_maturity(length):
    if length < 1:
        return '0 - 1 years'
    elif 1 <= length <= 3:
        return '1-3 years'
    else:
        return '>3 years'

df = pd.read_csv("ovgz.csv")
df.columns = (
    df.columns.str.replace(",", "")
            .str.replace(" ", "_")
)
df['Currency']=df['Currency'].astype(str).str.lower()
df['Month']=df['Month'].astype(str).str.lower()
df=df[df['Yield']!=0]
df=df[df['Volume_currency']!=0]
df['Placement_Period'] = df['Placement_Year'].astype(str) + '-' +
df['Placement_Month'].astype(str)
df['Placement_Date'] = pd.to_datetime(df['Placement_Date'])
df['Maturity_Date'] = pd.to_datetime(df['Maturity_Date'])
df['bond_length_days'] = (df['Maturity_Date'] - df['Placement_Date']).dt.days
df['bond_length_years'] = df['bond_length_days'] / 365.25
```

```
df['Placement_Period_bin'] = df.apply(
    lambda row: get_four_month_bin(row['Placement_Year'], row['Placement_Month']),
axis=1)
df['Maturity_Group'] = df['bond_length_years'].apply(classify_maturity)
df_by_period_currency = (
    df.groupby(['Placement_Period_bin', 'Currency'], as_index=False).agg(
        volume_sum=('VolumeUSD', 'sum'),
        issuance_count=('VolumeUSD','count')))
pivot_currency = df_by_period_currency.pivot(
    index='Placement_Period_bin', columns='Currency', values='volume_sum'
).fillna(0)

# Calculate percentage of total volume per period
pivot_currency_percent = pivot_currency.div(
    pivot_currency.sum(axis=1), axis=0
).fillna(0)
pivot_volume = df_by_period_currency.pivot(
    index='Placement_Period_bin', columns='Currency', values='volume_sum'
).fillna(0)

# Pivot for frequency
pivot_count = df_by_period_currency.pivot(
    index='Placement_Period_bin', columns='Currency', values='issuance_count'
).fillna(0)

# Sort index if needed (optional, useful for chronological plots)
pivot_volume = pivot_volume.sort_index()
pivot_count = pivot_count.sort_index()

# Plot volume
plt.figure(figsize=(12, 6))
for currency in pivot_volume.columns:
    plt.plot(pivot_volume.index, pivot_volume[currency], label=currency, marker='o')
plt.title('Bond Issuance Volume Over Time by Currency')
plt.xlabel('Placement Period')
plt.ylabel('Total Volume (USD)')
plt.legend(title='Currency')
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()

# Plot frequency
plt.figure(figsize=(12, 6))
for currency in pivot_count.columns:
    plt.plot(pivot_count.index, pivot_count[currency], label=currency, marker='o')
plt.title('Frequency of Bond Issuance Over Time by Currency')
plt.xlabel('Placement Period')
plt.ylabel('Number of Issuances')
plt.legend(title='Currency')
```

```
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()

total_volume = pivot_volume.sum(axis=1)
total_count = pivot_count.sum(axis=1)
aver_isss = total_volume/total_count

# --- Plot 3: Total volume ---
plt.figure(figsize=(12, 6))
plt.plot(total_volume.index, total_volume, label='Total Volume (USD)', color='blue',
marker='o')
plt.title('Total Bond Issuance Volume Over Time')
plt.xlabel('Placement Period')
plt.ylabel('Total Volume (USD)')
plt.xticks(rotation=45)
plt.grid(True)
plt.ylim(bottom=0)
plt.tight_layout()
plt.show()

# --- Plot 4: Total frequency ---
plt.figure(figsize=(12, 6))
plt.plot(total_count.index, total_count, label='Total Frequency (Count)', color='green',
marker='s')
plt.title('Total Frequency of Bond Issuance Over Time')
plt.xlabel('Placement Period')
plt.ylabel('Number of Issuances')
plt.xticks(rotation=45)
plt.ylim(bottom=0)
plt.grid(True)
plt.tight_layout()
plt.show()

average_size = total_volume / total_count

plt.figure(figsize=(12, 6))
plt.plot(average_size.index, average_size, label='Average Issuance Size (USD)',
color='purple', marker='d')
plt.title('Average Bond Issuance Size Over Time')
plt.xlabel('Placement Period')
plt.ylabel('Average Size (USD)')
plt.xticks(rotation=45)
plt.grid(True)
plt.ylim(bottom=0)
plt.tight_layout()
plt.show()

# (C) Stacked Bar Chart - % Breakdown by Currency
```

```
plt.figure()
pivot_currency_percent.plot(
   kind='bar', stacked=True, legend=True
)
plt.title("Quarterly Volume Breakdown by Currency (%)")
plt.xlabel("Period")
plt.ylabel("Percentage of Total Volume")
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()

df_by_period_maturity = (
   df.groupby(['Placement_Period_bin', 'Maturity_Group'], as_index=False)
     .agg(
        volume_sum=('VolumeUSD', 'sum'),
        issuance_count=('VolumeUSD', 'count')
     )
)


# Pivot tables for volume and frequency
pivot_volume_maturity = df_by_period_maturity.pivot(
   index='Placement_Period_bin', columns='Maturity_Group', values='volume_sum'
).fillna(0).sort_index()

pivot_count_maturity = df_by_period_maturity.pivot(
   index='Placement_Period_bin', columns='Maturity_Group', values='issuance_count'
).fillna(0).sort_index()

# --- Plot 6: Volume by maturity ---
plt.figure(figsize=(12, 6))


for maturity in pivot_volume_maturity.columns:
   plt.plot(pivot_volume_maturity.index, pivot_volume_maturity[maturity], label=maturity,
marker='o')
plt.title('Bond Issuance Volume Over Time by Maturity')
plt.xlabel('Placement Period')
plt.ylabel('Total Volume (USD)')
plt.legend(title='Maturity Bin')
plt.xticks(rotation=45)
plt.grid(True)
plt.ylim(bottom=0)
plt.tight_layout()
plt.show()

# --- Plot 7: Frequency by maturity ---
plt.figure(figsize=(12, 6))
for maturity in pivot_count_maturity.columns:
```

```
    plt.plot(pivot_count_maturity.index, pivot_count_maturity[maturity], label=maturity,
marker='o')
plt.title('Frequency of Bond Issuance Over Time by Maturity')
plt.xlabel('Placement Period')
plt.ylabel('Number of Issuances')
plt.legend(title='Maturity Bin')
plt.xticks(rotation=45)
plt.grid(True)
plt.ylim(bottom=0)
plt.tight_layout()
plt.show()

vwam_by_period = ( df.groupby('Placement_Period_bin') .apply(lambda x:
(x['bond_length_years'] * x['VolumeUSD']).sum() / x['VolumeUSD'].sum())
.reset_index(name='vwam_years') )

vwam_by_currency = ( df.groupby(['Placement_Period_bin','Currency']) .apply(lambda x:
(x['bond_length_years'] * x['VolumeUSD']).sum() / x['VolumeUSD'].sum())
.reset_index(name='vwam_years') )

pivot_df = vwam_by_currency.pivot(
    index='Placement_Period_bin',
    columns='Currency',
    values='vwam_years'
)

plt.figure(figsize=(10, 6))

for currency in pivot_df.columns:
    plt.plot(pivot_df.index, pivot_df[currency], marker='o', label=currency)

plt.title("Volume-Weighted Average Maturity by Currency Over Time")
plt.xlabel("Placement Period")
plt.ylabel("VWAM (Years)")
plt.xticks(rotation=45)
plt.legend(title="Currency")
plt.grid(True)
plt.tight_layout()
plt.show()

currencies = ['uah', 'usd', 'eur']

fig, axes = plt.subplots(nrows=3, ncols=1, figsize=(12, 18), sharey=True)
fig.suptitle('Volume-Weighted Average Coupon Yield Over Time by Maturity Group',
fontsize=16)

for i, currency in enumerate(currencies):
    # Filter data for the current currency
    df_curr = df[df['Currency'] == currency].copy()
```

```
    # Calculate volume-weighted average coupon per period and maturity group
    vwac_data = (
        df_curr.groupby(['Placement_Period_bin', 'Maturity_Group'])
        .apply(lambda x: (x['Yield'] * x['VolumeUSD']).sum() / x['VolumeUSD'].sum())
        .reset_index(name='VWAC')
    )

    # Pivot to have Maturity_Bins as columns
    pivot_vwac = vwac_data.pivot(index='Placement_Period_bin', columns='Maturity_Group',
values='VWAC')

    # Sort index and columns
    pivot_vwac = pivot_vwac.sort_index()
    pivot_vwac = pivot_vwac[maturity_order] if
set(maturity_order).issubset(pivot_vwac.columns) else pivot_vwac

    # Plot
    ax = axes[i]
    for maturity in pivot_vwac.columns:
        ax.plot(pivot_vwac.index, pivot_vwac[maturity], label=maturity, marker='o')

    ax.set_title(f'{currency}')
    ax.set_xlabel('Placement Period')
    if i == 0:
        ax.set_ylabel('VW Avg Coupon (%)')
    ax.set_ylim(bottom=0)
    ax.grid(True)
    ax.legend(title='Maturity Bin')
    ax.tick_params(axis='x', rotation=45)

plt.tight_layout(rect=[0, 0.03, 1, 0.95])
plt.show()

df_uah_ownership = pd.read_csv("uah_ownership.csv")
df_uah_ownership.columns = (
    df_uah_ownership.columns.str.replace(",", "")
            .str.replace(" ", "_"))
df_uah_ownership['Placement_Date'] =
pd.to_datetime(df_uah_ownership['Placement_Date'])

df_uah_ownership.set_index('Placement_Date', inplace=True)

# Select the relevant columns to plot
columns_to_plot = ['legal_Entities', 'Banks', 'Foreign_Institutions', 'Private_Investors', 'NBU']

# Plot each column as a line
plt.figure(figsize=(12, 6))
for column in columns_to_plot:
    plt.plot(df_uah_ownership.index, df_uah_ownership[column], marker='o', label=column)
```

```
# Add labels and legend
plt.title("Ownership of OVGZ by Investor Type Over Time")
plt.xlabel("Placement Date")
plt.ylabel("Amount")
plt.legend(title="Investor Type")
plt.grid(True)
plt.tight_layout()
plt.xticks(rotation=45)
plt.show()
```

Source: compiled by the authors

Appendix C.

Stata code for data preparation and structural break analysis

```
// Standard data preparation:
generate double date_stata = date(date, "DMY")
format date_stata %td
replace ytm = "" if ytm == "Missing data"
destring ytm, replace
format ytm %9.2f
// format data to appropriate data formats and handle missing ytm values labelled as “Missing data”
sort date_stata
generate timeindex = _n
ipolate ytm timeindex, gen(ytm_interp)
replace ytm = ytm_interp
drop ytm_interp
tsset timeindex
// generate timeindex and perform linear interpolation on the yields data
//sequential tests with different trimming:
xtbreak ytm, trimming(0.15) vce(hac)
xtbreak ytm, trimming(0.10) vce(hac)
xtbreak ytm, trimming(0.05) vce(hac)
//Fixed number of breaks model:
xtbreak ytm, breaks(5) trimming(0.10) vce(hac)
//Narrowing sample example:
drop if date_stata < td(01mar2021)
drop timeindex
generate timeindex=_n
tsset timeindex
//Visualization example (plotting YTM with 5 breaks – 148 316 570 780 1008):
twoway (line ytm timeindex), xline(148 316 570 780 1008)
```

Source: compiled by the authors

Appendix D.

Raw data collected for the research.

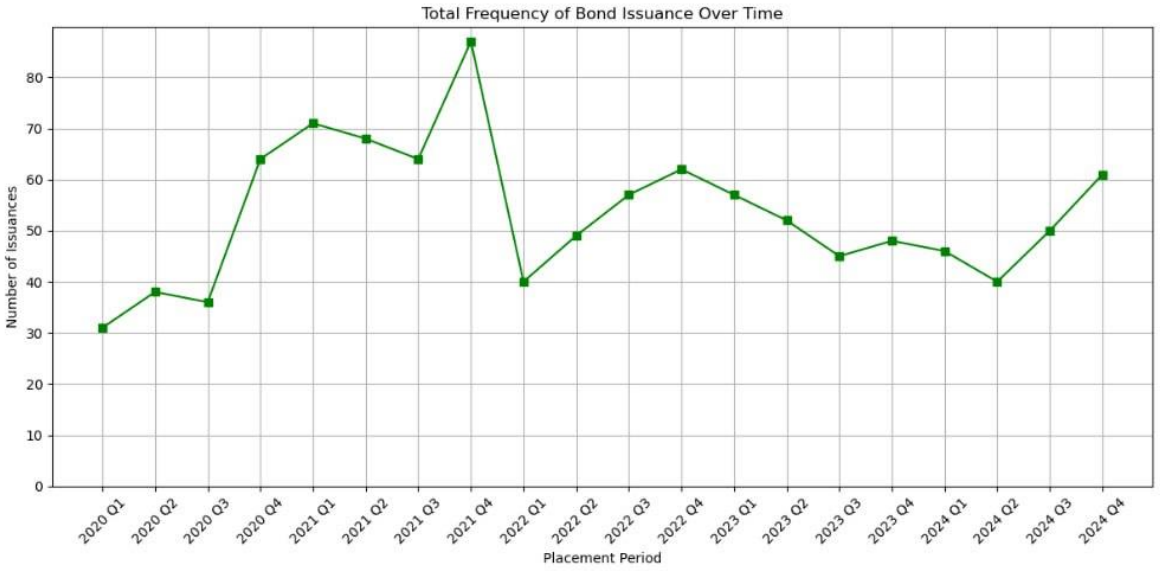
Link to the OneDrive folder:
https://tartuulikool-my.sharepoint.com/:f:/g/personal/romankyr_ut_ee/EvPFrgSl9shPsrDa-wKYHoIBViXqlpftqursL_exrX7tDg?e=sXzEzT

If you encounter any technical difficulties with the link, please contact the authors directly via email:
roman.kyrylchenko@ut.ee – Roman Kyrylchenko
artem.Lishchuk@ut.ee – Artem Lishchuk

Source: compiled by the authors

Appendix E.

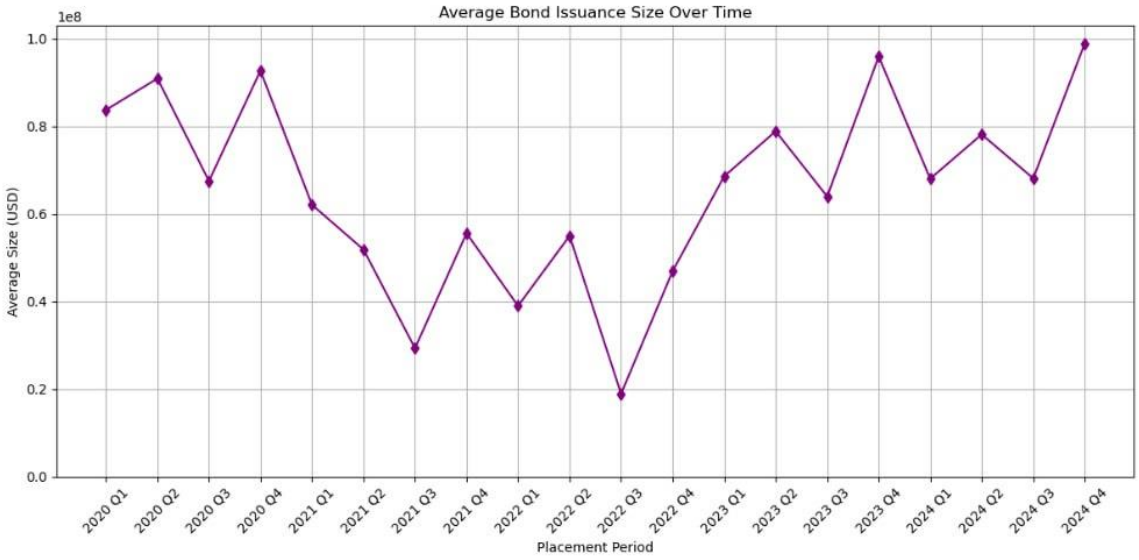
Number of OVGZ issued quarterly



Source: compiled by the authors based on the data from the Ministry of Finance of Ukraine

Appendix F.

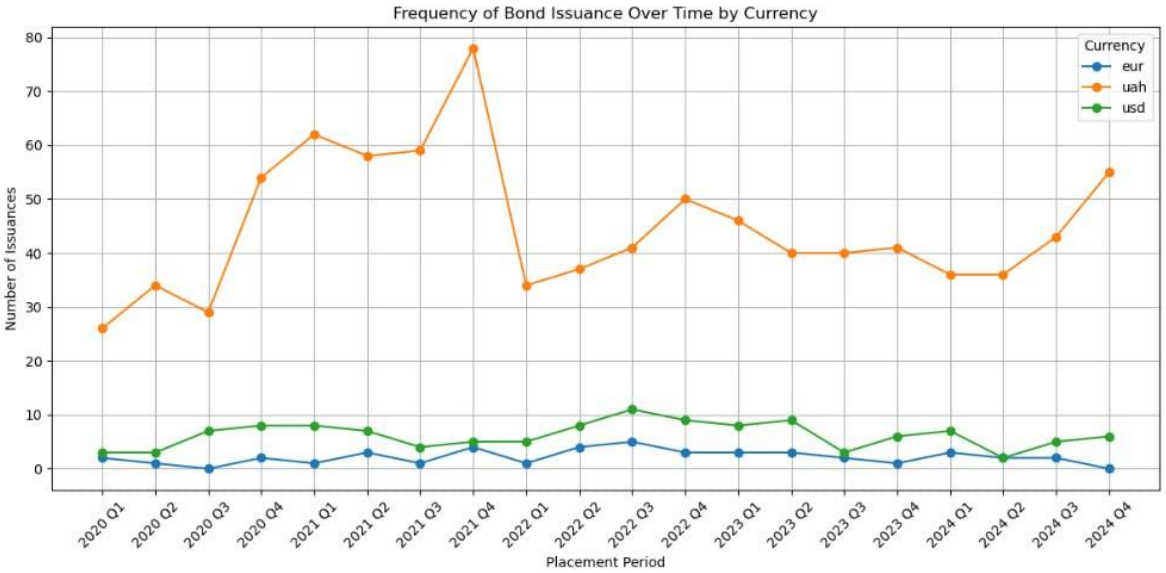
Average OVGZ issuance amount quarterly



Source: compiled by the authors based on the data from the Ministry of Finance of Ukraine

Appendix G.

Number of bonds of different currencies issued quarterly



Source: compiled by the authors based on the data from the Ministry of Finance of Ukraine

Resümee

UKRAINA RIIKLIKE VÕLAKIRJADE TURU TRANSFORMATSIOON SÕJALISTES TINGIMUSTES 2022. A VENEMAA SISSETUNGI UKRAINASSE NÄITEL

Artem Lishchuk, Roman Kyrylchenko

See bakalaureusetöö näitab, et sõjategevusel on märkimisväärne mõju riigivõlakirjade turule. Teoreetilisest vaatenurgast tõi bakalaureusetöö esile, et sõjategevus võib häirida makromajanduslikku stabiilsust. Konfliktid kipuvad intressimäärasid ja riskipreemiaid järsult tõstma, tekitama inflatsioonisurvet ning suurendama riigi maksejõuetuse riski eskaleeruvate fiskaalkoormuste ja majanduskahjude tõttu. Need tegurid tõstavad võlakirjade tootlust ja laiendavad krediidiriski hinnavahesid mõjutatud turgudel. Samal ajal järgib investorite käitumine sellistes kriisides teatud mustreid: äärmuslik ebakindlus käivitab "põgenemise kvaliteeti" ja "põgenemise likviidsusesse" dünaamika, kus investorid paigutavad kapitali konfliktist mõjutatud turgudelt turvalisematesse ja likviidsematesse varadesse. Rahvusvahelised investorid viivad tavaliselt raha välja ("põgenemine koju" efekt), samas kui kodumaised investorid võivad muutuda peamiseks rahastamisallikaks, mõnikord motiveerituna patriotismist. Ajaloolised sõja- ja kriisijuhtumid – alates Teise maailmasõja aegsetest võlakirjaturgude häiretest kuni lokaliseeritumate konfliktideni – näitavad sarnaseid suundumusi tootluste kasvus, likviidsuspingetes ja ulatuslikus valitsuse sekkumises.

Empiirilisest vaatenurgast tuvastasid Ukraina riigivõlakirjade tootluste struktuurimuutuste testid (teostatud eraldi UAH ja USD nomineeritud võlakirjadele) mitu kriitilist nihet, mis vastasid sõja peamistele faasidele. Ukraina riigivõlakirjade turu elutsükli võib laias laastus jagada kaheks perioodiks: vahetult pärast sõda (2022–2023) - esialgne kriis - ja pärast 2023. aastat - osalise taastumise ja krediiditingimuste edasise paranemise periood.

Täiemahulise sõja puhkedes 2022. aasta veebruari lõpus tõusid võlakirjade tootlused järsult. 2023. aasta keskel toimus tootlustrendides märkimisväärne murrang: pärast enam kui aasta kestnud kõrgenenud tootlusi hakkasid Ukraina võlakirjade tootlused langema umbes 2023. aasta juunis-juulis. See langes kokku mitmete märkimisväärsete sündmustega, sealhulgas muutustega rindejoontel ja jätkuva rahvusvahelise rahalise toetusega Ukrainale. Edasine muutus toimus 2024. aasta lõpus, võlakirjade tootlused langesid tagasi sõjaeelsele tasemele, kui Ukraina saavutas rahvusvaheliste kreeditoridega olulise välisvõla restruktureerimise kokkuleppe (koos märkimisväärse võlakergenduse ja restruktureeritud maksetingimustega). Lisaks tootluste liikumisele põhjustas sõda muutusi võlakirjaomanike struktuuris Ukrainas: välisinvestorid, kes olid enne sissetungi Ukraina riigivõlakirjade

olulised omanikud, lahkusid turult pärast sõja puhkemist peaaegu täielikult. Kodumaised institutsioonid (nagu kohalikud pangad ja keskpank) ning kodumaised investorid täitsid selle tühimiku, suurendades oma osa Ukraina valitsusele laenamises.

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Roman Kyrylchenko, Artem Lishchuk

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