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Abstract

War-related expectations cause changes to investors' risks and returns preferences. In this study, we examine the implications of war and sanctions sentiment for the G7 countries' debt markets during the Russia-Ukraine war. We use behavioral indicators across social media, news media, and internet attention to reflect the public sentiment from 1st January 2022 to 20th April 2023. We apply the quantile-on-quantile regression (QQR) and rolling window wavelet correlation (RWWC) methods. The quantile-on-quantile regression results show heterogenous impact on fixed income securities. Specifically, extreme public sentiment has a negative impact on G7 fixed income securities return. The wavelets correlation result shows dynamic correlation pattern among public sentiment and fixed income securities. There is a negative relationship between public sentiment and G7 fixed income securities. The correlation is time-varying and highly event dependent. Our additional analysis using corporate bond data indicates the robustness of our findings. Furthermore, the contagion analysis shows public sentiment significantly influence G7 fixed income securities spillover. Our findings can be of great significance while framing strategies for asset allocation, portfolio performance and risk hedging.

Keywords: *Russia-Ukraine war, economic sanctions, G7 debt, fixed income securities, quantile approaches*

1 Introduction

War events have long been recognized to have implications for financial markets (Frey & Kucher, 2001; Hudson & Urquhart, 2015; Schneider & Troeger, 2006). In essence, war-related expectations cause changes to investors' risks and returns preferences. This suggests that war related events are the most important specific event that move the financial market in a significant way (e.g., Boubaker et al., 2022; Boungou & Yatié, 2022; Zaremba et al., 2022). More specifically, Frey and Kucher (2001) find that war events are priced in government bonds. Hudson and Urquhart (2015), on the other hand, evidenced limited linkages between war events and stock market returns in the UK. From a global financial market perspective while accounting for multiple war events, Schneider and Troeger (2006) evidenced significant negative stock market reactions. Typically, earlier studies on the impact of war events on financial markets are limited to what transpired between markets during the war event (see for example, Izzeldin et al., 2023; Karkowska & Urjasz, 2023; Kumari et al., 2023; Lo et al., 2022). A recent strand in the literature uses behavioral indicators (i.e., media coverage, fake news, panic, sentiment, and media hype) to contextualize investor sentiments (Boungou & Yatié, 2022; Huynh et al., 2021; Khalfaoui et al., 2023) and thus, provides a direct measure of investor sentiments towards extreme events; however, in the framework of investor sentiments to war and sanctions, these behavioral indicators have been used in isolation to gauge investor sentiment.[1] Again, prior studies provide no understanding of how the financial market in general reacts to positive and negative investor sentiment towards economic sanction during the war in Ukraine.

This paper explores the implication of war and economic sanctions sentiments from a multidimensional perspective using a recently developed public sentiment index (RUWESent) constructed by combining Twitter Sentiments, Google Trend, Wikipedia Trend, and News Sentiments (Abakah et al., 2022). By this, we can account for public sentiment as an additional variable in the network analysis to provide a direct role of public sentiment in extreme events. Specifically, we contribute to this literature by examining the impact of war- and sanctions-induced uncertainty on the fixed-income markets in the G7 countries. We focus on debt markets because globally, fixed-income markets are the largest subgroup of financial markets by issuances and market capitalization. Fixed-income markets are three times larger than global equities markets making it a systematically important market with implications for the global

[1] For example, Boungou and Yatié (2022) and Khalfaoui et al. (2023) use Wikipedia trends and Google trends, respectively, to measure public attention towards the Russia-Ukraine war.

economy.[2] Nonetheless, the growing body of literature on the impact of the Russia-Ukraine war presents sparse evidence on the possibility of a relationship between war- and sanctions-induced public sentiment and fixed income securities under varying market conditions (see for example, Boubaker et al., 2022; Boungou & Yatié, 2022; Zaremba et al., 2022). Additionally, the time-frequency aspect of such a relationship is also missing. In this regard, two complimentary theoretical positions are apparent on the importance of investor sentiments on financial market dynamics. The first theoretical position is broadly consistent with the view that investors make financial decisions based on sentiments, which suggest that investor sentiments affect financial market dynamics (Huynh et al., 2021; Liang et al., 2020) in line with the theoretical model of noise traders (Long et al., 1990). The second theoretical position is consistent with the heterogeneous market hypothesis (Müller et al., 1993), which suggests that war and sanction related sentiments may alter investors' risk and return preferences across bullish, bearish, and normal market conditions.

A key question that needs to be addressed is, why the G7 fixed income market is particularly sensitive to the ongoing war and the possible channels through which it could be influenced by the war in Ukraine. First, we note that the G7 countries are at the forefront of the sanctions regime that has been imposed on Russia as well as the financial and military support Ukraine is receiving in it fight with Russia. Consequently, these governments have increased spending on defense and other war-related expenses.[3] This can result in higher levels of debt and inflation, which can contribute to an increase in interest rates.[4] In turn, this can influence the pricing of interest-rate-sensitive fixed-income securities such as bonds. Secondly, war-related events can also make investors more risk-averse (Verdickt, 2020; Wang & Young, 2020). In uncertain times, investors may pursue safer investments (Costantini & Sousa, 2022; Mohamad, 2022), such as government bonds, resulting in a rise in demand for fixed income securities. This can result in higher bond prices and lower yields(Leippold & Matthys, 2022; Zaremba et al., 2022). On the possible channels, the Ukraine crisis may raise geopolitical risk and uncertainty, causing a fixed income market flight to safety(see e.g., Feng et al., 2023). This may stimulate demand for safe-haven assets like US Treasuries, lowering yields. Moreover, the

[2] https://www.cfainstitute.org/en/membership/professional-development/refresher-readings/fixed-income-markets-issuance-trading-funding

[3] https://www.sipri.org/news/2023/world-military-expenditure-reaches-new-record-high-european-spending-surges-0

[4] https://www.cgdev.org/publication/ukrainian-war-and-feds-interest-rate-hikes-double-whammy-emerging-markets-and

global supply networks have been disrupted causing increased inflation, supply chain costs, and central bank interest rates. Consequently, investors in fixed-income securities may sell off.

Our paper contributes to literature in four main ways. First, we contribute to the literature that examines the impact of war on the debt markets (Frey & Kucher, 2001). We focus on war- and sanctions-induced sentiments and show a negative effect on fixed income securities return in both bullish and bearish markets; however, when the range of sentiment is considered normal, the effect is positive, suggesting an asymmetric static impact of war and sanctions sentiment on fixed income securities. This finding supports the heterogeneous market hypothesis(Müller et al., 1993), and suggests that war and sanction related sentiments may alter investors' risk and return preferences across bullish, bearish, and normal market conditions. Second, we extent the literature that examines the impact of war- and sanctions-induced uncertainty on financial market (Boubaker et al., 2022; Boungou & Yatié, 2022; Zaremba et al., 2022). The rolling window wavelet correlation is used to provide evidence on the dynamics of the relationship between war- and sanctions-related sentiments and debt markets. We find a strong negative correlation between investor sentiments and fixed income securities returns at the start of the invasion and during major invasion events, implying that war- and sanctions-induced investor sentiments had a time-varying influence. As a result, negative sentiment has a negative impact on fixed income securities, indicating that it causes irrational investor behavior as well as increase noise trader loss aversion and herding behavior(Long et al., 1990). Furthermore, the negative correlation in the higher decomposition level during the financial turbulence period suggests that returns on fixed income securities assets would offer hedging opportunities with other safe-haven assets and diversification opportunities for short- and long-term investors (Baur & Lucey, 2010). Third, we contribute to the literature studying the contagion effect of the Russia-Ukraine war on the global financial markets (see e.g., Boungou & Yatié, 2022; Khalfaoui et al., 2023). We demonstrate that the fixed income markets of Japan, UK, US and UK are net risk receivers, whereas Italy, Germany France are the major transmitter of risk suggesting that there is contagion effect from the Eurozone's to other G7 countries during Russia Ukraine war. Lastly, we provide novel evidence on the subset of the public sentiment towards war and sanction. This includes the Russia-Ukraine War sentiment index, Russia-Ukraine War Sanction sentiment index, and Russia-Ukraine War anxiety index. The results indicate the effect is stronger for Russia-Ukraine War sentiment index and the highest negative impact is witnessed on the fixed income market in Germany.

The remainder of the study is structured as follows. Section 2 provides a brief overview of the literature. Section 3 reports the data and methodology, and section 4 discusses the results. Finally, section 5 concludes the paper.

2 Brief overview of the literature

Our paper is related to recent strand of the literature on the impact of the Russia-Ukraine war sentiments on financial markets. These studies reveal the potential impact of war events on the financial markets. Earlier studies in this literature widely acknowledge that war events have a significant effect on the interactions at the core of financial markets around the world (Ahmed et al., 2022; Boungou & Yatié, 2022; Choudhry, 2010; Frey & Kucher, 2000, 2001; Hudson & Urquhart, 2015; Schneider & Troeger, 2006).Since the outbreak of the Russia-Ukraine war, a few studies have examined the impact of the conflict on markets(Ahmed et al., 2022; Boubaker et al., 2022; Boungou & Yatié, 2022; Chortane & Pandey, 2022; Costola & Lorusso, 2022; Halousková et al., 2022; Kumari et al., 2022; Tosun & Eshraghi, 2022; M. Umar et al., 2022; Yousaf et al., 2022), but none of them examined the impact of the conflict on the debt market. This strand of the literature examines cryptocurrency assets in the context of a network of traditional financial assets (Adekoya et al., 2022; Diaconaşu et al., 2022; Mohamad, 2022; Z. Umar et al., 2022); and focus on what transpired between markets during the period. It should also be noted that the Caldara and Iacoviello (2022) geopolitical risk (GPR) index, Google Trends, and news events have been used as the principal proxies for sentiments during the Russia-Ukraine war (see, Aslanidis et al., 2022; Będowska-Sójka et al., 2022; Halousková et al., 2022; Long et al., 2022; Qureshi et al., 2022).

Regarding the implications of the war on stock markets, Kumari et al. (2022) demonstrated that in the case of the Russia-Ukraine war (the invasion), the stock markets of the closest European countries (Poland, Denmark, and Portugal) to the war region experienced event day impact, but recovered in the post-event period, showing positive cumulative abnormal returns (CARs). Furthermore, Boubaker et al. (2022) demonstrated that the invasion produced CARs for global stock market indices, albeit with varying effects. They specifically evidenced that markets in NATO countries had higher returns. The positive outcomes observed after these countries' events indicate an improvement in market sentiment as investors regained confidence that NATO would not pursue armed conflict. Nevertheless, the sanctions had adverse effects on stock returns, signaling that investors anticipated trade disruptions and a decline in the value of firms. Additionally, attention biases caused by salience resulted in investors favoring stocks with considerable growth potential while undervaluing stocks with significant drawbacks. As a result, higher returns were observed in the subsequent period (M. Umar et al., 2022).

Additional research has explored the impact of the invasion on various markets, including clean energy, conventional energy, and metals. These studies have shown that investors have given greater importance to the likelihood of outcomes associated with the clean energy sector due to the war's developments. As a result, the objective probability of outcomes has been distorted (M. Umar et al., 2022). Adekoya et al. (2022) examined how oil markets related to bonds, Bitcoin, the US dollar, gold, and stocks before and during the Russia-Ukraine war using intraday data. They reported that the link between oil and other financial assets is stronger than before the war. Oil, rather than being a net receiver of spillovers, becomes a net transmitter of spillovers during the war. The net directional pairwise results show that oil connects to the remaining assets in a variety of ways before the war, but it has a large spillover effect on all of them during the war. They also demonstrate that the spillover effect diminishes over time.

Another body of literature has focused on examining the hedging characteristics of various asset classes within the context of the Russian-Ukraine conflict. These studies have provided insights into effective strategies for mitigating geopolitical risk. Notably, different asset classes have demonstrated varying degrees of sensitivity to risk, both in terms of magnitude and timescale. Bonds and stocks, for instance, have exhibited strong correlation over multi-week periods, while currencies have been affected over shorter timescales (Będowska-Sójka et al., 2022). Finally, Qureshi et al. (2022) compiled a database of news events related to the conflict and explored the systemic risk implications on financial sector indices. The events were categorized as political actions, military actions, sanctions, military support for Ukraine, financial support for Ukraine, and Russian invasion. They demonstrated that the conflict's systemic instability costs extend beyond Russia and Ukraine and that, sanctions have a systemic risk spillover effect on European countries and the United States.

In this study, we investigate the implications of war and economic sanctions sentiment for the G7 debt market using a sentiment index developed to reflect the public sentiment across social media, news media, and internet attention.

3 Data and Methodology

3.1 Data

The war between Russia and Ukraine is the result of long-standing tensions between the two countries, which began in late December 2021 and culminated in Russia's invasion of Ukraine on February 24, 2022. To represent the proxy of Russia-Ukraine war induced economic sanctions sentiments we use novel measure of Russia-Ukraine War Economic Sanctions News Sentiment Index (RUWESsent) which is developed based on Twitter Sentiments (TS), Google Trend (GT), Wikipedia Trend (WT), and News Sentiments (NS).In RUWESsent, TS represents public sentiment toward war and sanctions, GT and WT indicate anxiety (stress) or intensity due to intense interest in war and sanctions, and NS represents media sentiment toward war and sanctions (See Abakah et al., 2022). To avoid biases, we chose a study sample period from January 1, 2022 to April 20, 2023, where the ending period is based on the availability of RUWESsent. The value of RUWESsent is ranging from 1 to 100, with a low value (1 to 49) representing negative sentiment and a high value (50 to 100) representing positive sentiment. The indicators of RUWESsent are illustrated in Figure 1, which shows RUWESsent was at its peak on February 24, 2022. Finally, for debt market, we use daily data oftreasury / sovereign / quasi-government bond indices of G7 countries[5]. We chose G7 countries because they are at the forefront of the sanctions regime that has been imposed on Russia as well as the financial and military support Ukraine is receiving in it fight with Russia. Table 1 contains a summary of the selected securities and RUWESsent with data sources.

[Insert Table 1 About Here]

[Insert Figure 1 About Here]

[Insert Figure 2 About Here]

As the level series of variables are non-stationery according to Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) unit-root test, we transformed the series using percentage change as $r_{i,t} = 100 \times (P_{i,t} - P_{i,t-1})/(P_{i,t-1})$,which are presented in Figure 2. We can see similar return movement of selected assets in some specific periods. Table 2 presents the summary statistics for all the series. In Panel A, the fixed income securities exhibit a negative mean return, indicating a negative return throughout the sample period. On the other

[5] We use S&P Dow Jones indices to proxy the G7 fixed income securities. See https://www.spglobal.com/spdji/en/index-family/fixed-income/treasury-sovereign-quasi-government/#overview.

hand, the mean return of RUWESsent is positive. Additionally, all the series demonstrate positive skewness, indicating a distribution with a longer tail on the right side. The ADF and PP unit root tests provide strong evidence supporting the stationarity process for all the series.Finally, we examine the Pearson correlation and results are presented in Panel B, which shows a positive correlation with all fixed income security indices and RUWESsent.

[Insert Table 2 About Here]

3.2 Methods

This paper uses two robust estimation techniques to examine the effect, and dynamic correlation between the RUWESsent on fixed income securities market: (1) Quantile on Quantile Regression(Sim & Zhou, 2015)and (2) Rolling window wavelet correlation approach(Polanco-Martínez et al., 2018). Moreover, we also examine the robustness of our results using quantile granger causality test based on Troster (2018) and examined contagion across G7 debt market using Time-Varying Parameter Vector Autoregressions (TVP-VAR) based connectedness approach based on Antonakakis et al. (2020)[6].

3.2.1 Quantile on Quantile Regression (QQR)

First, we use the QQR method proposed by Sim and Zhou (2015) to examine the overall impact of the RUWESsent on fixed income securities market. The QQR is a more advanced version of simple quantile regression (QR) that is created by combining non-parametric estimations with basic QR. The traditional QR model can investigate the effect of the independent variable on different quantiles and the dependent variable's conditional mean (Sim & Zhou, 2015). The QQR model, on the other hand, combines traditional linear regression with the QR model, which can analyze the impact of both dependent and independent variables over conditional distributions and provides a better understanding of the interactions between the dependent and independent variables. While QR can show how the RUWESsent have affected different quantiles of fixed income securities returns, we cannot see how the numerous different quantiles of RUWESsent have affected fixed income securities returns. The QQR contributes to this by regressing different quantiles of RUWESsent on different quantiles of fixed income securities returns. This is necessary because, depending on the market condition (bear, normal, or bull), higher and lower sentiments have different magnitude effects on assets return

[6]See Troster (2018) for detailed methodology of quantile granger causality test and Antonakakis et al. (2020) for TVP-VAR based connectedness approach.

(Bossman et al., 2023). Sim and Zhou (2015) proposed the non-parametric function of the QQR model as:

$$r_t = \beta^{\theta} RUWESsent_{t-1} + \alpha^{\theta} r_{t-1} + \varepsilon_t^{\theta} \quad (4)$$

where r_t denotes daily returns of fixed income securities and $RUWESsent_t$ denotes changes in the sentiments at the time t. Moreover, θ denotes fixed income securities returns at θ_{th} quantile and $\beta^{\theta}(.)$ is unknown. $RRUWESsent^{\tau}$ is calculated first-order Taylor approximation using the following equation:

$$\begin{aligned} &\beta^{\theta} RUWESsent_{t-1} \\ &\approx \beta^{\theta} RUWESsent^{\tau} + \beta^{\theta}(RUWESsent^{\tau})(RUWESsent_{t-1} - RUWESsent^{\tau}) \\ &\equiv b_0(\theta,\tau) + b_1'(\theta,\tau) \times (RUWESsent_{t-1} - RUWESsent^{\tau}) \quad (5) \end{aligned}$$

where, τ represents the τ_{th} quantile of Russia-Ukraine war and sanctions sentiments. Afterward, the substitution of first-order Taylor approximation in Equation 4 with Equation 5 outputs Equation 6.

$$\begin{aligned} r_t = {} & \beta^{\theta}(RUWESsent^{\tau}) + \beta^{\theta}(RUWESsent^{\tau})(RUWESsent_{t-1} - RUWESsent^{\tau}) + \alpha^{\theta} r_{t-1} \\ & + \varepsilon_t^{\theta} \quad (6) \end{aligned}$$

where Equation 3 is explained by following equitation:

$$\begin{aligned} \min_{b_0(\theta,\tau), b_1\ (\theta,\tau), \alpha^{\theta}(\tau)} & \sum_{t=1}^{T} \rho_{\theta} \left[r_t - b_0 - b_1(RUWESsent_{t-1} - RUWESsent^{\tau}) \right. \\ & \left. - \alpha^{\theta} r_{t-1} \right] K\left(\frac{RUWESsent(RUWESsent_{t-1}) - \tau}{h} \right) \quad (7) \end{aligned}$$

where $\rho_{\theta}(.)$ solved θth quantile of $r_t$represents the absolute value of the slope function and the Gaussian kernel function $K(.)$ with h is the bandwidth. Here, h is selected using the cross-validation method.

3.2.2 Rolling window wavelet correlation (RWWC)

The application of the QQR can reveal salient information about how the RUWESsent impacts different quantiles of fixed income securities returns. However, the effect of the RUWESsent might be time-varying. Therefore, we apply RWWC proposed by Polanco-Martínez et al. (2018), which is elaborated as follows.

First, based on the work of Polanco-Martínez et al. (2018), we compute Maximal overlap discrete wavelet transform (MODWT) wavelet correlation, to examine the impact Russia-Ukraine war and sanctions induced sentiments on fixed income securities returns at different time periods. The equitable wavelet correlation for scale λ_j between two time series X and Y is presented as follows:

$$\tilde{\rho}_{XY} = \frac{\text{cov}\left(\tilde{W}_{Y,jt}, \tilde{W}_{Y,jt}\right)}{\sqrt{\text{var}\left\{\tilde{W}_{X,jt}\right\}\text{var}\left\{\tilde{W}_{X,jt}\right\}}} = \frac{\tilde{\gamma}_{XY}(\lambda_j)}{\tilde{\sigma}_X^2(\lambda_j)\tilde{\sigma}_Y^2(\lambda_j)} \quad (8)$$

In the preceding expression, $\tilde{\gamma}_{XY}(\lambda_j)$signifies the equitable approximator of wavelet covariance between market coefficient $\tilde{W}_{Y,jt}$ and $\tilde{W}_{Y,jt}$, whereas $\tilde{\sigma}_X^2(\lambda_j)$ and $\tilde{\sigma}_Y^2(\lambda_j)$ are the unbiased estimators of wavelet variances X and Y, respectively, associated with the scale λ_j. MODWT defines as follows:

$$\tilde{\sigma}_X^2(\lambda_j) = \frac{1}{\tilde{N}_j} \sum_{t=L_{j-1}}^{N-1} \tilde{W}_{j,t}^2 \quad (9)$$

where $\tilde{W}_{j,t}^2$signifies$j$ th scale of MODWT coefficient for $X, L_j = (2j-1)(L-1) + 1$signifies length of scale λ_j. Following Daubechies (1992) we construct confidence interval $100(1-2p)\%$ for wavelet coherence. An expression for $100(1-2p)\%$ confidence interval for wavelet coherence is given by tan $h\left\{h\left[\tilde{\rho}_{XY}(\lambda_j)\right]\emptyset^{-1}(i-p)/\sqrt{N_j-3}\right\}$, where $\emptyset^{-1}(p)$ represents $100p\%$ points for standard normal distribution and $\text{h}(\tilde{\rho}_{XY}) = \tanh^{-1}(\tilde{\rho}_{XY})$ denotes the Fisher Z-transformation (Daubechies, 1992; Gençay et al., 2001).

We employ a dynamic rolling window wavelet correlation method to assess correlation across multiple dimensions in both time and frequency domains, allowing us to analyze how the correlation changes over time. This measure has proven to be highly advantageous in various finance studies due to its ability to analyze different time intervals effectively (Polanco-Martínez et al., 2018; Rehman, 2020). In our analysis, we set two decomposition levels (j=2) and a 22-day rolling window per month, moving one data point at a time and centering it around a specific time.

4 Results

4.1 Quantile on Quantile Regression (QQR) Results

The results of the QQR method are presented in Figures 3. The graphs show the slope coefficients $\beta_1(\theta,\tau)$, which represent the impact of the τ_{th} quantile of RUWESsent on fixed income securities returns, where the high and low quantiles of θ_{th} represent the bullish and bearish fixed income securities market, respectively. Furthermore, because of the non-parametric process used in QQR estimations, it is not practical to examine the significance levels of the coefficients(Bossman et al., 2023; Sim & Zhou, 2015). According to Figure4, each quantile of the RUWESsent has a different effect on fixed income securities returns across quintiles, which suggests a heterogeneous effect across quantiles. For example, in the case of US, there is a negative relationship when both RUWESsent and US are in the upper quantile (0.85 to 0.95), whereas there is a positive effect when both are in lower quantile (.05 to 0.35. The results for other G7 countries fixed income securities show a similar heterogeneous effect across quantiles, e.g., Canada, France, Germany, Italy and UK. In contrast, the results for Japan show a positive impact in both extreme lower and higher quantiles and heterogenous impact across rest of the quantiles.

The robustness of our QQR results is examined by comparing with the coefficient of the quantile regression (QR) following Bossman et al. (2023), and the results are presented in Figure A.1 in Appendix. The graph shows the mean coefficient of each quantile of QQR and coefficient of QR.As the QQR results do not deviate significantly from the QR, this indicates the robustness of QQR results. Additionally, supplementary to the QRR estimates, we adopted the quantile Granger causality test for further robustness and present the results in Table A.1 and Table A.2 (Appendix). The finding shows there is unidirectional causal relationship with RUWESsent and G7 fixed income securities. This result indicates war and sanction related sentiments granger cause fixed income securities, but fixed income securities does not granger cause sentiments. This result is consistent with earlier studies by Zhang et al. (2018)who documented sentiments can predict asset price movement.

[Insert Figure 3 About Here]

Overall, the QQR result shows that the upper extreme quantiles (0.05 and 0.95) of RUWESsent have a negative effect on G7fixed income securities return in a bullish market and bearish market, except Japan. Our findings indicate European, UK, and US has considerable negative shock from Russia-Ukraine war. However, there is a positive impact on fixed income securities when sentiment is considered normal (0.35 to 0.65). As a result, our findings support the heterogeneous market hypothesis(Müller et al., 1993), and suggests that investors consider all available information, including the RUWESsent, when analyzing their risk and return preferences across bullish, bearish, and normal market conditions(Bossman et al., 2023).

However, the above QQR method results show the asymmetric static impact of the RUWESsent on fixed income securities, which fails to capture the time-varying relationship. As a result, in the following section, we investigate the time-frequency aspect of the relationship between war- and sanctions-induced investor sentiment and the fixed-income marketusing the dynamic rolling window wavelet correlation.

4.2 The rolling window wavelet correlation (RWWC) results

The results of RWWC are illustrated in Figures 4, where values are usually between negative and positive, indicating a negative and positive correlations. The RWWC shows some intriguing results that cannot be obtained with the QQR method. For example, the relationship's strength varies over time and is determined by how frequently changes in the RUWESsent coincide with fixed income securities returns. Correlation coefficients or time horizons are implied with changes of 1 to 5 days and intraweek to monthly periods for the two wavelet scales, or from D1 to D2. Higher scales, such as D2, describe processes that occur at a lower frequency, such as economic uncertainty, monetary policy, trade, and common shocks (Polanco-Martínez et al., 2018). This implies that volatility events are more closely associated with the first wavelet scales. The result shows France, Germany, and UKhave high negative correlations, followed by Canada, and Italy to a lesser extent, and US, and Japan have low negative correlations with the RUWESsent. The findings of QQR also shows similar pattern, where Japan is less affected by war and sanction sentiment. The dynamic result shows high negative correlation between RUWESsent and fixed income securities returns during the commence of the invasion and major invasion events. Furthermore, the results show a higher negative correlation in September 2022.

[Insert Figure 4 About Here]

Therefore, the RWWC findings show a stronger negative link immediately following the invasion and during September 2022, demonstrating that the RUWESsent index had a time-varying influence. As a result, negative sentiment has a negative impact on fixed income securities, signaling that negative sentiment causes irrational investor behavior as well as increasing noise trader loss aversion and herding behavior(Long et al., 1990). Furthermore, the negative correlation in the higher decomposition level during the financial turbulence period suggests that returns on fixed income securities assets would offer hedging opportunities with other safe-haven assets and diversification opportunities for short- and long-term investors (Baur & Lucey, 2010).

Overall, our results of QQR and RWWC could be explained by the ongoing Russia-Ukraine war and economic sanctions, which have increased investors' loss aversion and herding behavior. Earlier studies on other assets also uncover the negative impact of Russia Ukraine war (e.g., Boungou & Yatié, 2022; Yousaf et al., 2022). Moreover, previous research also found that negative sentiments increase loss aversion and herding behavior and have a negative impact on the other assets(Huynh et al., 2021; Liang et al., 2020). As a result, before investing, a strategic assessment of market circumstances is essential, taking into account systemic risks such as Russia-Ukraine War induced economic sanctions sentiments.

4.3 Additional robustness results

4.3.1 Impact of war, sanction, and anxiety on G7 fixed income securities

Our above analysis uses composite indicator RUWESsent to examine the effect of war and sanction public sentiment on G7 fixed income securities. However, the effect of war, sanction and anxiety from those events might be different. The influence of sentiments caused by the conflict and sanctions may differ, since each situation brings new obstacles and opportunities for fixed income securities. While the outbreak of violence may initially create a negative reaction in markets, the introduction of economic sanctions may have a different effect. Indeed, sanctions could reassure investors and lessen the harmful impact of the conflict. Thus, we use Russia-Ukraine War sentiment index (RUWESsent_War), Russia-Ukraine War Sanction sentiment index (RUWESsent_Sanction), and Russia-Ukraine War anxiety index (RUWESsent_Anxiety) and the result is presented in Table 3. The result indicates RUWESsent_War, RUWESsent_Sanction, and RUWESsent_Anxiety has negative impact on G7 fixed income securities. The coefficient indicates the effect is stronger for RUWESsent_War and highest negative impact is witnessed on Germany. This result can be explained by the dependency of Germany on Russian energy, due to sanction there was interruption in the energy supply in Germany making energy costing higher and reflecting negative effect in the overall economy of Germany[7]. Our findings suggest economic sanctions and war sentiments signal to the markets that the international community is taking action to address the conflict, which uncertainty and affecting fixed income securities price, leading

[7] Source: https://www.dw.com/en/ukraine-war-costs-germanys-economy-100-billion/a-64768176

increased investors' loss aversion and herding behavior. Previous studies (e.g., (Boungou & Yatié, 2022; Yousaf et al., 2022) also discover the negative impact of Russia Ukraine war.

[Insert Table 3 About Here]

4.3.2 Robustness test using alternative proxy

The above analysis is based on the data of G7 treasury / sovereign / quasi-government bond indices. However, the effect of war and sanction public sentiment on G7 corporate bond might be different than the treasury / sovereign / quasi-government bond. This is because corporate bonds are issued by private companies, rather than governments, and are therefore subject to different economic and market forces. Furthermore, corporate bonds are more vulnerable to shifts in investor opinion than sovereign or quasi-government bonds. This is due to the fact that corporate bonds are generally seen as riskier investments than government bonds, as they are dependent on the financial success of the underlying companies. Therefore, we use S&P 500 investment grade corporate bond index (US_IGCB), S&P U.K. investment grade corporate bond index (UK_IGCB), S&P Japan investment grade corporate bond index (Japan_IGCB), S&P EUROZONE investment grade corporate bond index (EUROZONE_IGCB), and S&P Canada investment grade corporate bond index (Canada_IGCB) to proxy the G7 corporate bonds. The result of robustness test using corporate bond data is presented in Table 4. The findings show there is a negative impact of RUWESsent, RUWESsent_War,RUWESsent_Sanction, and RUWESsent_Anxiety on G7 corporate bond returns. This result further corroborates our baseline findings and indicates there is a negative effect of war and sanction public sentiment on G7 fixed income securities. To further examine the robustness of our findings, we use Corporate Bond Market Distress Index (CBMDI) as the proxy of fixed income market turbulence and sentiment indicator. The CMDI is an indicator that measures the level of distress in the corporate bond market(Boyarchenko et al., 2022). The CMDI can impact bond market returns by influencing investor sentiment. When the CMDI rises, it can signal to investors that the corporate bond market is facing greater risks and uncertainties, which can lead to increased fear and caution, driving investors to shift their portfolios towards other assets. The result of the additional robustness test using CMDI is presented in Table A.3. The findings also show there is a negative impact of CMDI on G7 corporate bonds.

[Insert Table 4 About Here]

Overall, our additional robustness test corroborates our baseline results and suggests there is a negative effect of war and sanction public sentiment on G7 fixed income securities.

4.3.3 Contagion effect of Russia-Ukraine war on G7 fixed income market

The above analysis clearly shows there is a negative effect of war and sanction public sentiment on G7 fixed income securities. However, the contagion effect of Russia-Ukraine war on G7 fixed income market and how war and sanction public sentiment drives or reduces the contagion is still unclear. Thus, we further examine the contagion effect of Russia-Ukraine war on G7 fixed income market using TVP-VAR based connectedness approach based on Antonakakis et al. (2020). For contagion analysis we examine the volatility spillover across G7 fixed income market.

[Insert Table 5 About Here]

First, we estimate the volatility of each indices using Univariate- Threshold GARCH model and estimate the static volatility connectedness using TVP-VAR model. The result of static volatility connectedness is presented in Table 4. The interaction between network variables is depicted in off-diagonal components, whereas own-variance shocks are presented in the on-diagonal. For example, the result of on-diagonal element shows US has the highest own variance shock (37.67%), whereas France has the lowest own variance shock (21.02%). This finding suggests that 37.67% of the forecast error variance in the US can be attributed to shocks within its own asset class. The row labeled "TO" indicates that France (94.50%) exhibits the highest spillover to other assets in the network, while the row labeled "FROM" shows that France (77.98%) experiences the highest spillover from other assets in the network. Based on the negative or positive values of NET, assets are classified as net risk receivers or transmitters. When considering typical net recipients and transmitters, France (16.52%) emerges as the primary net transmitter within the network, while Japan (-15.75%) appears to be the main net recipient. To gain a better understanding of the risk transmission mechanism, the results are visualized in a network connectedness plot depicted in Figure 5. Arrows in the figure indicate the direction of transmission, color represents the nature of transmission (blue for net transmitters and yellow for net receivers), and the node size indicates the strength of risk transmission. The findings also show Japan is major receiver of risk and France is the major transmitter of risk. Overall, Japan, UK, US and UK are in the net risk receiver, whereas Italy, Germany France are the major transmitter of shock. The total connectedness index (TCI) shows

71.68% connectedness in the network, indicating considerable contagion across the G7 fixed income markets. Thus, result indicates there is contagion effect from Eurozone's to other G7 countries during Russia Ukraine war. However, the result is static and failed to uncover time-varying contagion effect, thus, we further examine dynamic connectedness.

[Insert Figure 5 About Here]

The result of dynamic connectedness is presented in Figure 6. The result shows there is a time varying connectedness among G7 fixed income securities. The findings clearly show there is a upsurge in connectedness after the Russian invasion of Ukraine, indicating contagion effect of Russia Ukraine war on G7 fixed income securities. The result of net directional connectedness and pairwise connectedness is presented in Figure A2, and A3, and both figure shows there is contagion effect of Russia Ukraine war on G7 fixed income securities. The net-pairwise connectedness result shows contagion effect from Eurozone's to other G7 countries during Russia Ukraine war.

[Insert Figure 6 About Here]

Finally, to examine the impact of war and sanction sentiment on G7 fixed income securities contagion, we regress TCI with the war and sanction sentiment indices and results are presented in Table 6. The findings indicate there is a positive impact of RUWESsent, RUWESsent_War, RUWESsent_Sanction, and RUWESsent_Anxiety on G7 fixed income securities contagion. This result implies war and sanction sentiment drives contagion from European Markets to other G7 markets. Thus, during times of war and sanctions, negative sentiment in European markets can have a spillover effect on other G7 markets. This means that investor sentiment towards the conflict and sanctions can drive changes in market performance and affect other markets beyond just Europe. Our finding is consistent with earlier studies who documented negative influence of Russia-Ukraine war on other financial markets (Ahmed et al., 2022; Boubaker et al., 2022; Boungou & Yatié, 2022; Costola & Lorusso, 2022; Yousaf et al., 2022). Overall, findings suggest investors must carefully consider the potential contagion effects of war and sanctions when making investment decisions.

[Insert Table 6 About Here]

5 Conclusion

Given the increasing role of social media platforms in exchanging information and ideas among investors, academicians and researchers in recent years have implemented many investor sentiment proxies based on news shared on social media outlets. We use behavioral indicators across social media, news media, and internet attention to reflect the public sentiment and examine the implications of war and sanctions sentiment for the G7 debt market during the Russia-Ukraine war. We apply the quantile-on-quantile regression (QQR) and rolling window wavelet correlation (RWWC) methods. This allows differentiating between correlation patterns in the upper, median, and lower quantiles. The RWWC is used to provide evidence on the dynamics of the relationship between war- and sanctions-related sentiments and the G7 debt market. We find a strong negative correlation between public sentiments and fixed income securities returns at the start of the invasion and during major invasion events, implying that war- and sanctions-induced public sentiments had a time-varying influence. Furthermore, we find evidence of negative correlation in the higher decomposition level during the financial turbulence period. Our additional analysis uncovers the robustness of our findings using alternatives proxies and our contagion analysis shows significant influences of war and sanction sentiment on spillover.

The findings of this study have significant implications. For portfolio investors, the time-varying relationship observed between our sentiment index and the G7 debt market can assist market participants in adopting more effective hedging strategies and portfolio diversification techniques, ultimately leading to improved returns during periods of market volatility. In summary, our research holds substantial importance in the formulation of asset allocation strategies, portfolio performance enhancement, and risk hedging. It should be noted that the assumption of homogeneity among market participants and economic agents lacks empirical evidence. Therefore, any analysis exploring the relationship between sentiments and financial assets should consider the possibility that economic agents are not homogeneous. From a policy perspective, policymakers can benefit from understanding whether a strong dependency exists between investor sentiments and G7 debt, particularly under extreme negative shocks. This understanding can guide decision-making regarding the implementation of specific policies aimed at protecting investors from severe fluctuations in the financial market, especially during times of wars and war-related events. Lastly, this research can contribute to the development of policies aimed at mitigating the financial impact of the Russia-Ukraine war on the transmission of shocks between financial markets.

Our study is not without limitations. While our focus is on the G7 debt market, it would be valuable to expand the analysis to encompass other financial markets and asset classes. Doing so would provide a more comprehensive understanding of the impact of sentiments across various domains.

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Tables/Figures

Table 1: List of variables

Variables	Description	Data Source
Canada	S&P Canada Sovereign Bond Index	Datastream
France	S&P France Sovereign Bond Index	Datastream
Germany	S&P Germany Sovereign Bond Index	Datastream
Italy	S&P Italy Sovereign Bond Index	Datastream
Japan	S&P Japan Sovereign Bond Index	Datastream
UK	S&P U.K. Gilt Index	Datastream
US	S&P U.S. Treasury Bond Index	Datastream
RUWESsent	Russia-Ukraine War induced economic sanctions sentiments index	https://ruwessent.wordpress.com/

Table 2: Summary statistics and correlation analysis results

	Canada	France	Germany	Italy	Japan	UK	US	RUWESsent
Panel A: Summary statistics								
N	338	338	338	338	338	338	338	338
Mean	-0.04	-0.07	-0.06	-0.06	-0.06	-0.11	-0.03	2.27
Std.	0.66	0.81	0.77	0.87	0.83	1.33	0.4	22.43
Minimum	-1.84	-2.12	-1.81	-2.53	-2.25	-5.73	-1.17	-62.95
Maximum	2.49	2.76	2.57	3.12	3.54	6.86	1.4	146.32
Skewness	0.24	0.31	0.32	0.27	0.69	0.6	0.31	1.64
Kurtosis	0.53	0.41	0.43	0.57	2.11	4.62	0.48	7.87
ADF	-6.9***	-6.927***	-7.171***	-7.218***	-6.226***	-6.936***	-6.783***	-7.059***
PP	-316.698***	-320.707***	-325.782***	-307.263***	-340.791***	-318.816***	-324.643***	-404.497***
	Canada	France	Germany	Italy	Japan	UK	US	RUWESsent
Panel B: Correlation analysis								
Canada	1							
France	0.97***	1						
Germany	0.97***	1.00***	1					
Italy	0.95***	0.99***	0.99***	1				
Japan	0.95***	0.99***	0.99***	0.98***	1			
UK	0.98***	0.98***	0.98***	0.96***	0.96***	1		
US	0.97***	0.97***	0.97***	0.95***	0.97***	0.96***	1	
RUWESsent	0.44***	0.48***	0.48***	0.47***	0.51***	0.44***	0.47***	1

Note:N= Number of observations; Std.= Standard Deviation; Min= Minimum; Max= Maximum; ADF= Augmented Dickey–Fuller unit-root test; PP= Phillips–Perron unit-root test; ***,**,* denote significance at 1%, 5% and 10% significance level.

Table 3: Impact of War, Sanction, and Anxiety

Panel A: War

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Canada	France	Germany	Italy	Japan	UK	US
RUWESsent_War	-0.013**	-0.022***	-0.025***	-0.018**	-0.018**	-0.044***	-0.009**
	(0.006)	(0.009)	(0.009)	(0.008)	(0.008)	(0.016)	(0.004)
Constant	0.006	0.014*	0.012	0.011	0.010	0.036***	0.003
	(0.005)	(0.008)	(0.007)	(0.007)	(0.007)	(0.014)	(0.003)
Observations	337	337	337	337	337	337	337
R-squared	0.017	0.020	0.020	0.014	0.015	0.023	0.020
Adjusted R-squared	0.014	0.017	0.017	0.012	0.012	0.020	0.017

Panel B: Sanction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Canada	France	Germany	Italy	Japan	UK	US
RUWESsent_Sanction	-0.010***	-0.018***	-0.016***	-0.015***	-0.014***	-0.030***	-0.007***
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.007)	(0.002)
Constant	0.009*	0.019**	0.016**	0.015**	0.014**	0.043***	0.005
	(0.005)	(0.008)	(0.007)	(0.007)	(0.007)	(0.014)	(0.003)
Observations	337	337	337	337	337	337	337
R-squared	0.054	0.054	0.054	0.046	0.047	0.053	0.054
Adjusted R-squared	0.051	0.052	0.051	0.044	0.045	0.050	0.052

Panel C: Anxiety

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Canada	France	Germany	Italy	Japan	UK	US
RUWESsent_Anxiety	-0.007***	-0.012***	-0.011***	-0.009***	-0.009***	-0.021***	-0.004***
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.007)	(0.002)
Constant	0.007	0.016*	0.014*	0.012*	0.012*	0.039***	0.004
	(0.005)	(0.008)	(0.008)	(0.007)	(0.007)	(0.014)	(0.003)
Observations	337	337	337	337	337	337	337
R-squared	0.026	0.026	0.026	0.020	0.020	0.027	0.024
Adjusted R-squared	0.023	0.023	0.023	0.017	0.017	0.024	0.021

Note: This table presents the results of the impact of war, sanction, and anxiety on G7 fixed income securities. Panels A, B, and C shows the findings for war, sanction, and anxiety as independent variable using respective G7 fixed income securities return as dependent variable. All models are estimated using the Newey–West OLS estimator. Robust standard errors are in parentheses. ***,**,* denote significance at 1%, 5% and 10% significance level.

Table 4: Robustness test using corporate bond data

Panel A: RUWESsent

	(1)	(2)	(3)	(4)	(5)
Variables	US_IGCB	UK_IGCB	Japan_IGCB	EUROZONE_IGCB	Canada_IGCB
RUWESsent	-0.018***	-0.032***	-0.020***	-0.020***	-0.013***
	(0.004)	(0.008)	(0.005)	(0.005)	(0.003)
Constant	0.007	0.020**	0.009*	0.010*	0.005
	(0.005)	(0.009)	(0.005)	(0.006)	(0.004)
Observations	337	337	337	337	337
R-squared	0.060	0.049	0.052	0.049	0.047
Adjusted R-squared	0.057	0.047	0.049	0.046	0.044

Panel B: War

	(1)	(2)	(3)	(4)	(5)
Variables	US_IGCB	UK_IGCB	Japan_IGCB	EUROZONE_IGCB	Canada_IGCB
RUWESsent_War	-0.011**	-0.019*	-0.011*	-0.011	-0.007
	(0.005)	(0.011)	(0.006)	(0.007)	(0.005)
Constant	0.005	0.016*	0.006	0.007	0.003
	(0.005)	(0.009)	(0.006)	(0.006)	(0.004)
Observations	337	337	337	337	337
R-squared	0.012	0.010	0.009	0.008	0.007
Adjusted R-squared	0.009	0.007	0.006	0.005	0.004

Panel C: Sanction

	(1)	(2)	(3)	(4)	(5)
Variables	US_IGCB	UK_IGCB	Japan_IGCB	EUROZONE_IGCB	Canada_IGCB
RUWESsent_Sanction	-0.009***	-0.016***	-0.010***	-0.010***	-0.007***
	(0.002)	(0.005)	(0.003)	(0.003)	(0.002)
Constant	0.008	0.021**	0.009*	0.010*	0.006
	(0.005)	(0.009)	(0.006)	(0.006)	(0.004)
Observations	337	337	337	337	337
R-squared	0.044	0.036	0.040	0.036	0.035
Adjusted R-squared	0.041	0.033	0.037	0.033	0.032

Panel D: Anxiety

	(1)	(2)	(3)	(4)	(5)
Variables	US_IGCB	UK_IGCB	Japan_IGCB	EUROZONE_IGCB	Canada_IGCB
RUWESsent_ Anxiety	-0.006**	-0.010**	-0.006**	-0.006**	-0.004**
	(0.002)	(0.005)	(0.003)	(0.003)	(0.002)
Constant	0.006	0.018*	0.007	0.008	0.004
	(0.005)	(0.009)	(0.006)	(0.006)	(0.004)

Observations	337	337	337	337	337
R-squared	0.016	0.014	0.015	0.012	0.012
Adjusted R-squared	0.013	0.011	0.012	0.009	0.009

Note: This table presents the results of the impact of war, sanction, and anxiety on G7 corporate bonds. Panels A, B, C, and D shows the findings for composite indicator, war, sanction, and anxiety respectively as independent variable using respective G7 corporate bonds indices return as dependent variable. All models are estimated using the Newey–West OLS estimator. Robust standard errors are in parentheses. ***,**,* denote significance at 1%, 5% and 10% significance level.

Table 5: Static connectedness results

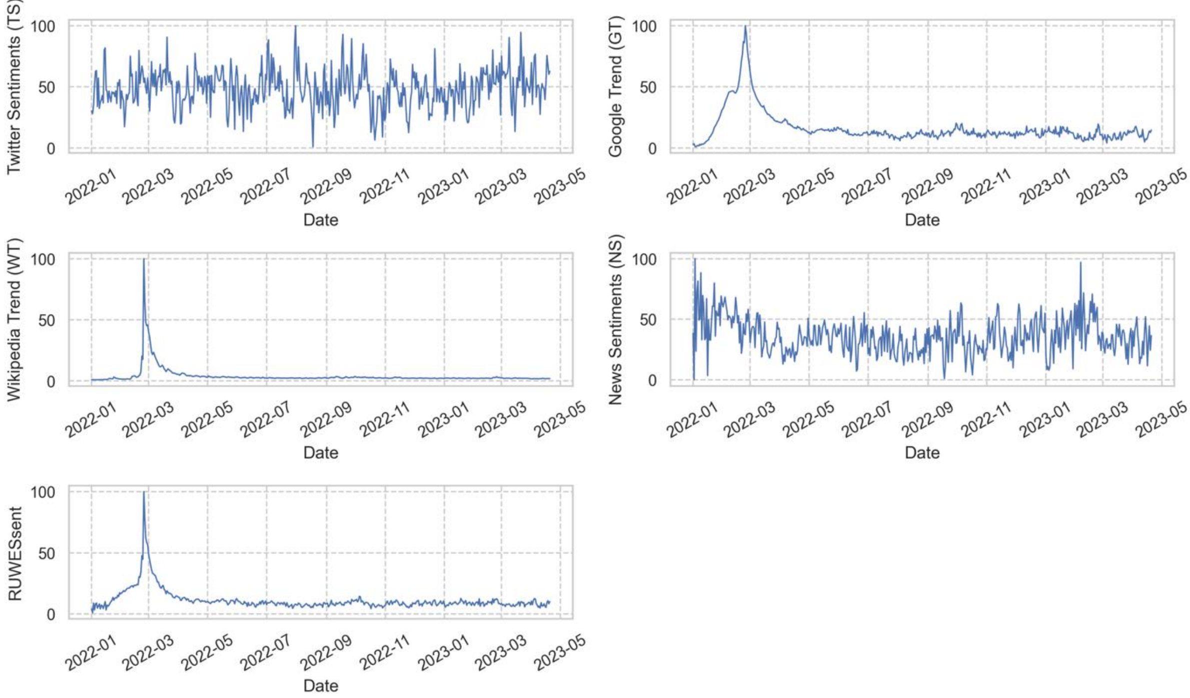
	Canada	France	Germany	Italy	Japan	UK	US	FROM
Canada	30.55	13.25	13.46	12.53	6.03	11.96	12.21	69.45
France	10.16	22.02	21.34	19.06	6.81	13.19	7.41	77.98
Germany	10.29	21.58	22.1	18.34	7.2	13.23	7.26	77.9
Italy	10.49	20.54	19.57	24.04	6.58	11.99	6.78	75.96
Japan	9.48	12.31	12.67	10.94	35.75	9.94	8.92	64.25
UK	11.56	16.09	15.75	13.82	6.55	26.09	10.14	73.91
US	14.53	10.72	10.24	9.22	5.58	12.05	37.67	62.33
TO	66.51	94.5	93.03	83.89	38.76	72.36	52.72	501.78
Inc.Own	97.06	116.52	115.13	107.93	74.51	98.46	90.39	TCI
NET	-2.94	16.52	15.13	7.93	-25.49	-1.54	-9.61	71.68

Notes: Results are based on a generalized forecast error variance decomposition with 10 steps in advance and a 22-day rolling-window TVP-VAR model with a lag length of order 1 (BIC). TO = spillover to other asset; FROM = spillover from other asset; NET = net directional spillover, TCI= total connectedness index.

Table 6: Impact of War sentiment, Sanction sentiment, and Anxiety on contagion across G7 debt market.

	(1)	(2)	(3)	(4)
Variables	TCI	TCI	TCI	TCI
RUWESsent	0.246***			
	(0.051)			
RUWESsent_War		0.246***		
		(0.050)		
RUWESsent_Sanction			0.212***	
			(0.038)	
RUWESsent_ Anxiety				0.215***
				(0.044)
Constant	68.876***	68.264***	69.598***	69.859***
	(0.564)	(0.671)	(0.387)	(0.379)
Observations	338	338	338	338
R-squared	0.372	0.367	0.293	0.287
Adjusted R-squared	0.370	0.365	0.291	0.284

Note: This table presents the results of Impact of War sentiment, Sanction sentiment, and Anxiety on contagion across G7 debt market. Model 1, 2, 3, and 4 is developed using composite indicator, war, sanction, and anxiety respectively as independent variable using respective G7 corporate bonds indices return as dependent variable. All models are estimated using the Newey–West OLS estimator. Robust standard errors are in parentheses. ***,**,* denote significance at 1%, 5% and 10% significance level.



Note: Source authors illustration from the data of RUWESsent website https://ruwessent.wordpress.com/

Figure 1: RUWESsent and its indicators

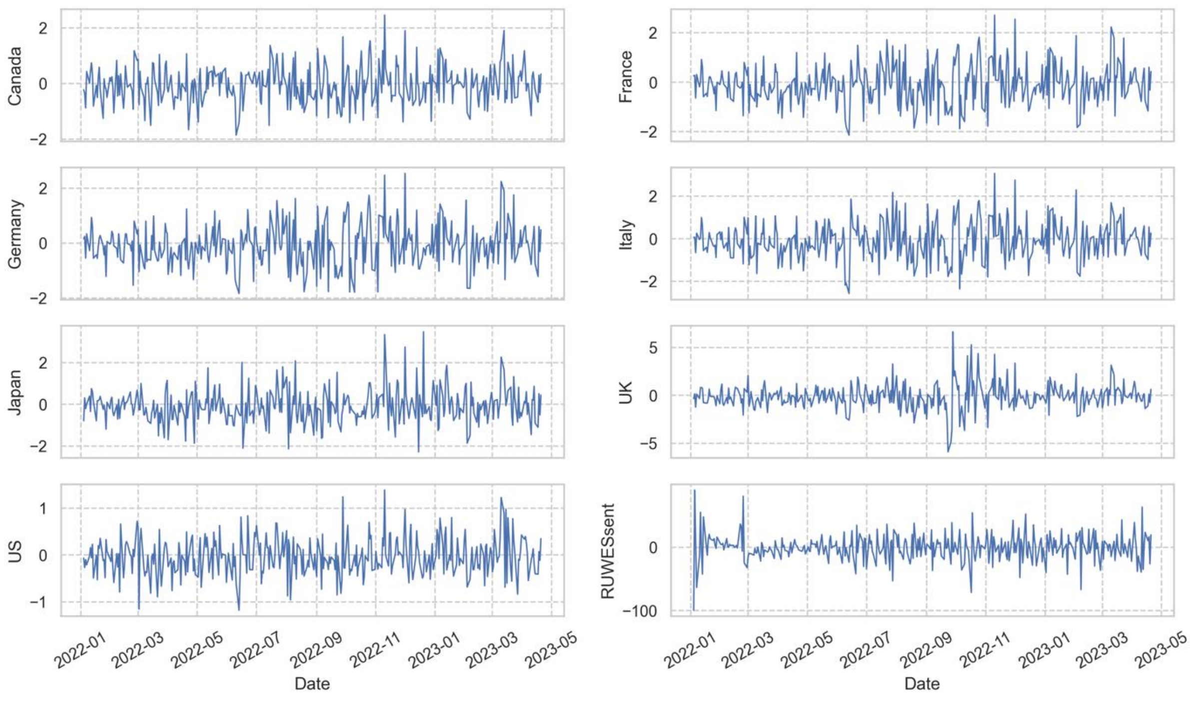
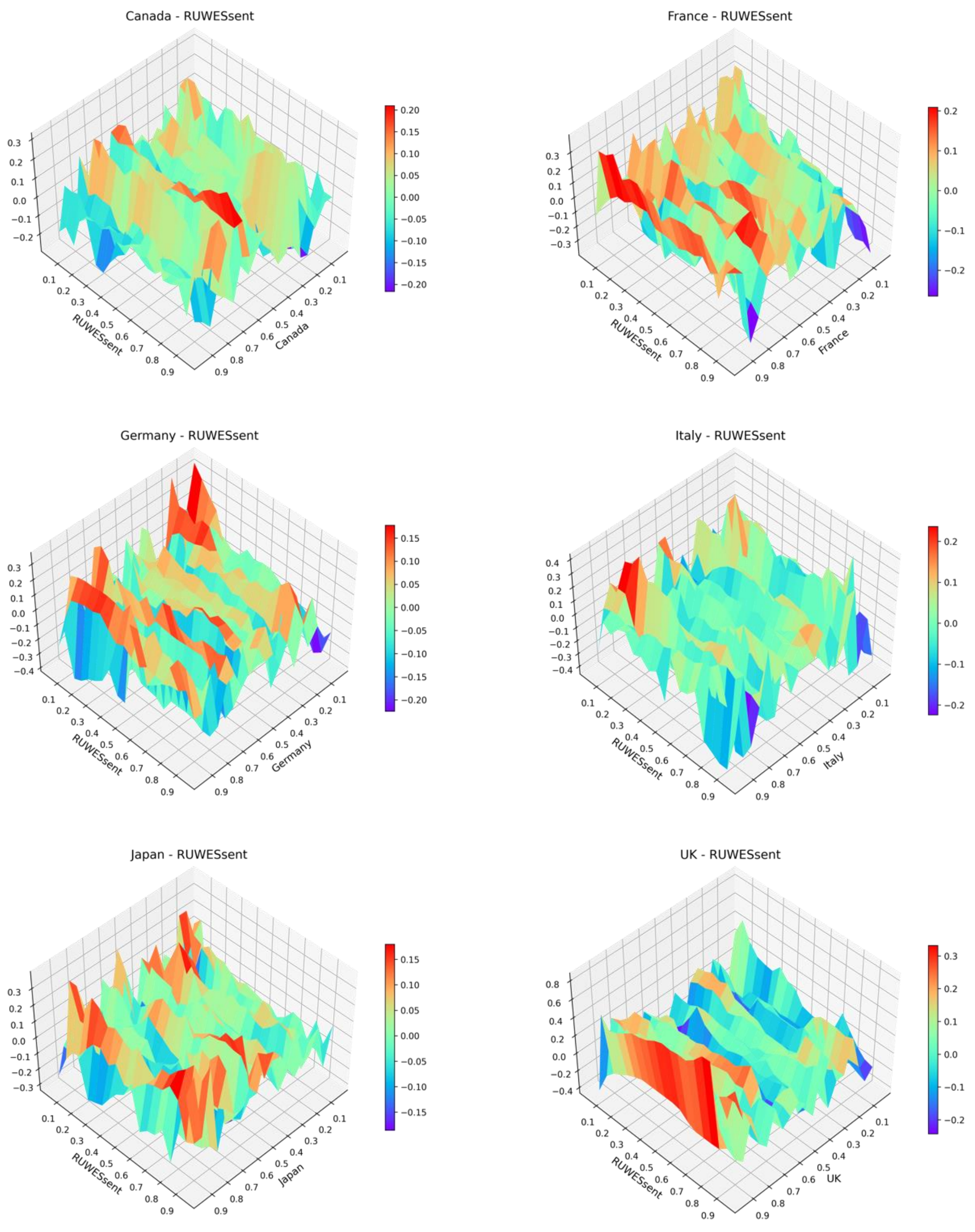


Figure 2: Historical series of daily percentage changes in variables



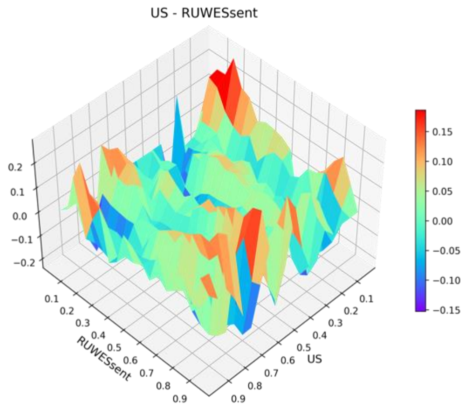


Figure 3: Quantile-on-quantile regression results between RUWESsent and US debt market

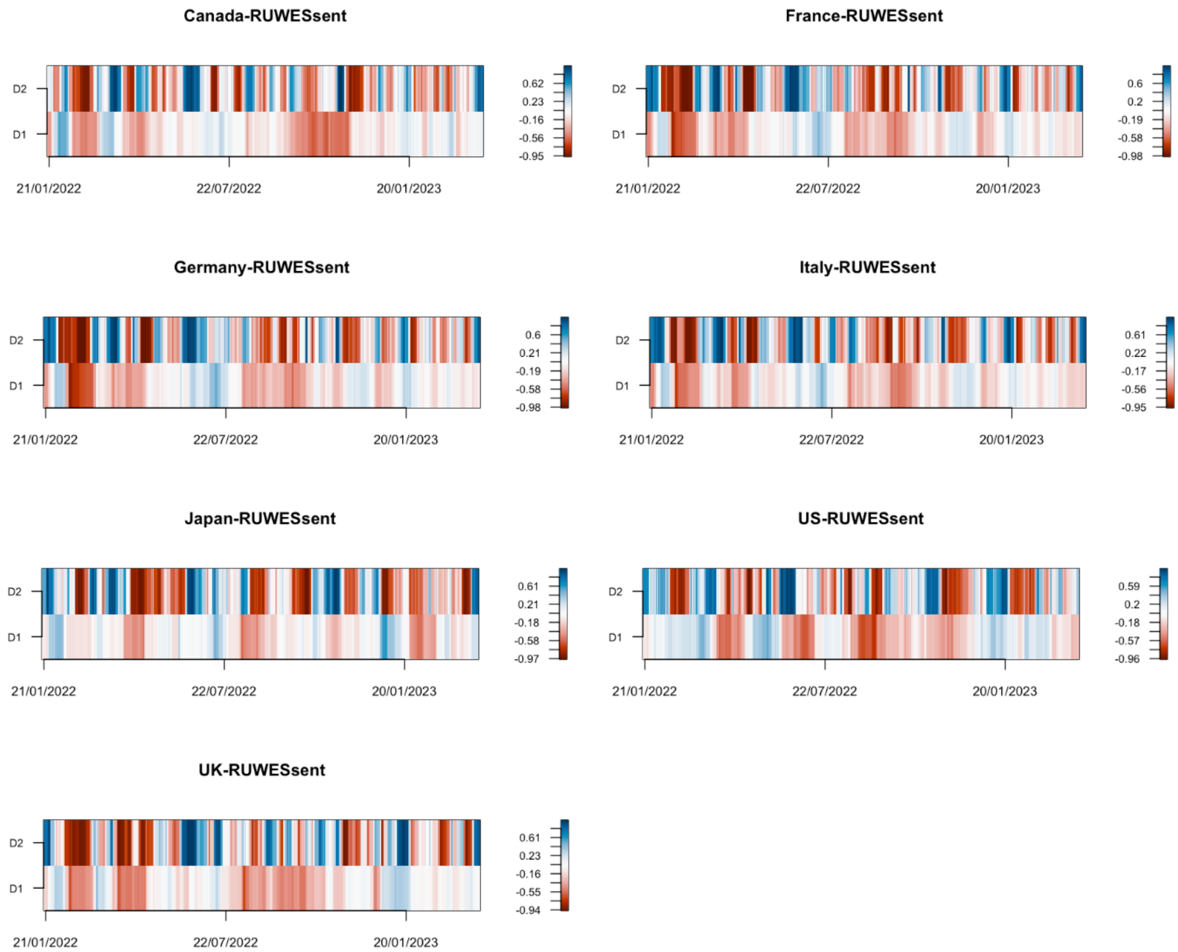
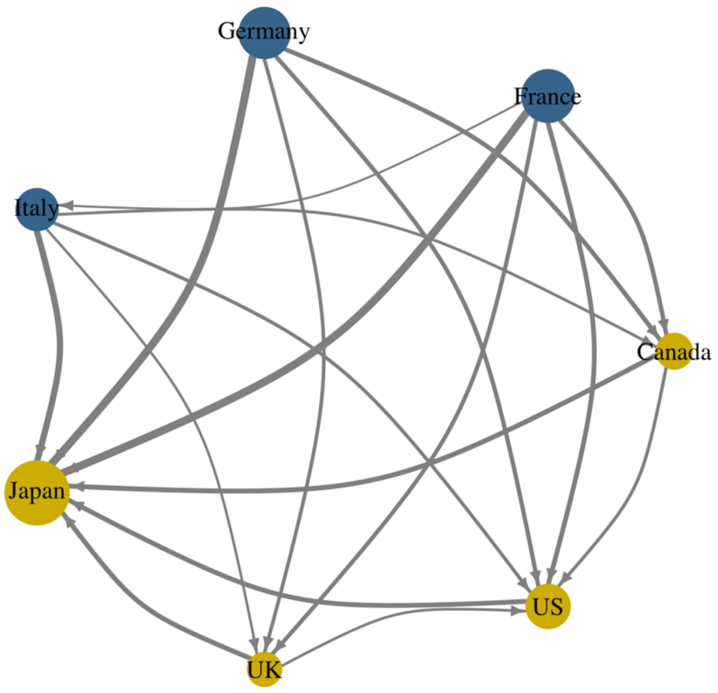
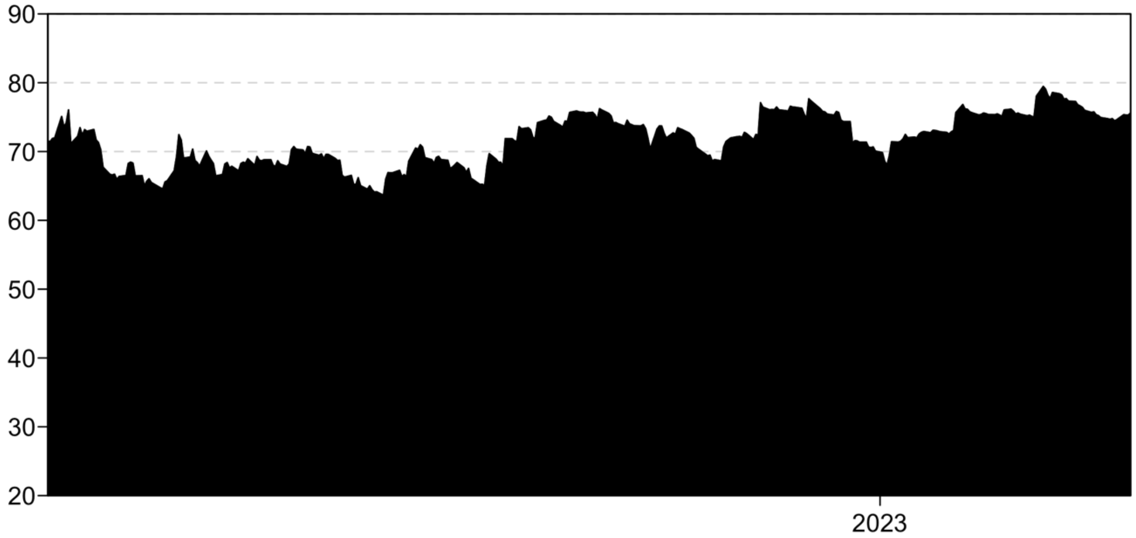


Figure 4: Rolling wavelet window correlation result results between RUWESsent and US debt market.



Notes: Results are based on a generalized forecast error variance decomposition with 10 steps in advance and a 22-day rolling-window TVP-VAR model with a lag length of order 1 (BIC).

Figure 5: Connectedness network plot



Notes: Results are based on a generalized forecast error variance decomposition with 10 steps in advance and a 22-day rolling-window TVP-VAR model with a lag length of order 1 (BIC).

Figure 6: Dynamic total connectedness index

Appendix

A1.Quantile on Quantile Regression robustness test

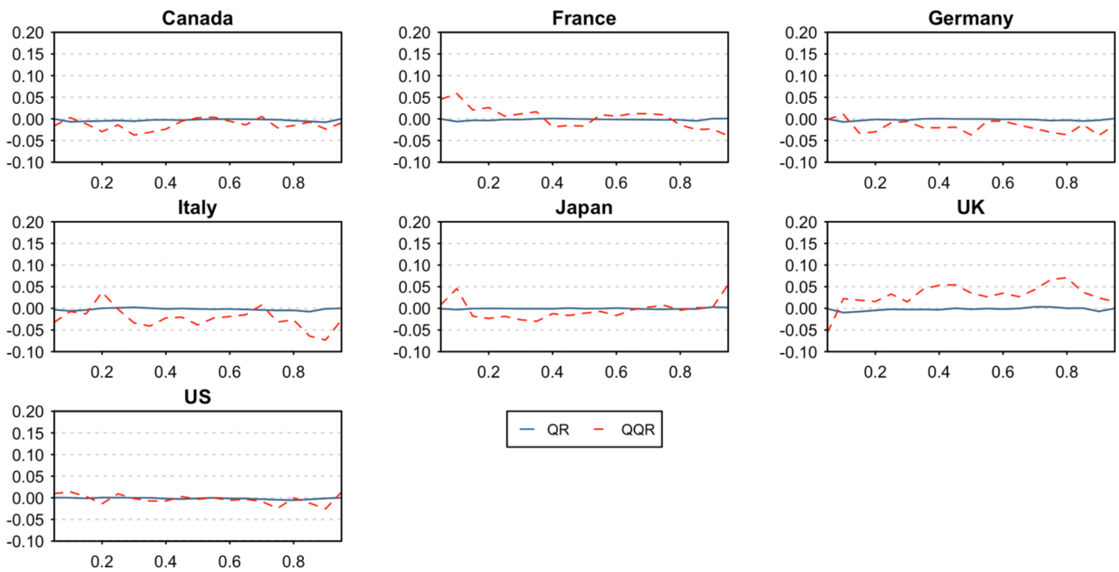


Figure A.1: QQR results robustness test

A2. Quantile Granger Causality Test Results

Table A.1: Quantile granger test results of RUWESsent to fixed income assets

τ	Canada	France	Germany	Italy	Japan	UK	US
0.05	1.21	1.18	1.15	1.27	1.57*	1.23	1.43*
0.10	1.74**	1.72**	1.79**	1.74**	2.17**	2.26**	2.02**
0.15	1.49*	1.37*	1.28	1.97**	1.48*	2.27**	1.65**
0.20	1.51*	1.43*	1.44*	1.64*	1.83**	2.12**	1.52*
0.25	1.8**	1.42*	1.43*	1.92**	1.61*	2.48***	1.90**
0.30	1.78**	1.83**	1.90**	2.18**	2.15**	2.83***	1.72**
0.35	1.87**	2.26**	2.43***	2.53***	2.35***	3.37***	1.93**
0.40	1.87**	2.43***	2.32**	2.43***	2.09**	3.31***	1.79**
0.45	2.08**	2.10**	1.98**	2.05**	1.95**	2.79***	1.80**
0.50	1.82**	2.18**	2.11**	2.21**	2.11**	2.91***	1.93**
0.55	2.00**	2.52***	2.66***	2.60***	2.18**	3.05***	2.15**
0.60	1.97**	2.2**	2.39***	2.09**	1.99**	2.66***	2.09**
0.65	2.25**	2.44***	2.64***	1.95**	2.23**	2.75***	2.35***
0.70	1.95**	2.13**	2.30**	1.78**	1.81**	2.71***	2.26**
0.75	2.04**	2.19**	2.30**	1.58*	1.84**	2.39***	2.04**
0.80	1.79**	1.84**	1.92**	1.31*	1.08	1.92**	2.02**
0.85	1.50*	1.69**	1.67**	1.47*	1.16	1.50*	1.56*
0.90	1.23	1.19	1.30*	0.93	0.94	1.26	1.28
0.95	0.71	0.56	0.56	0.57	0.87	0.58	0.68

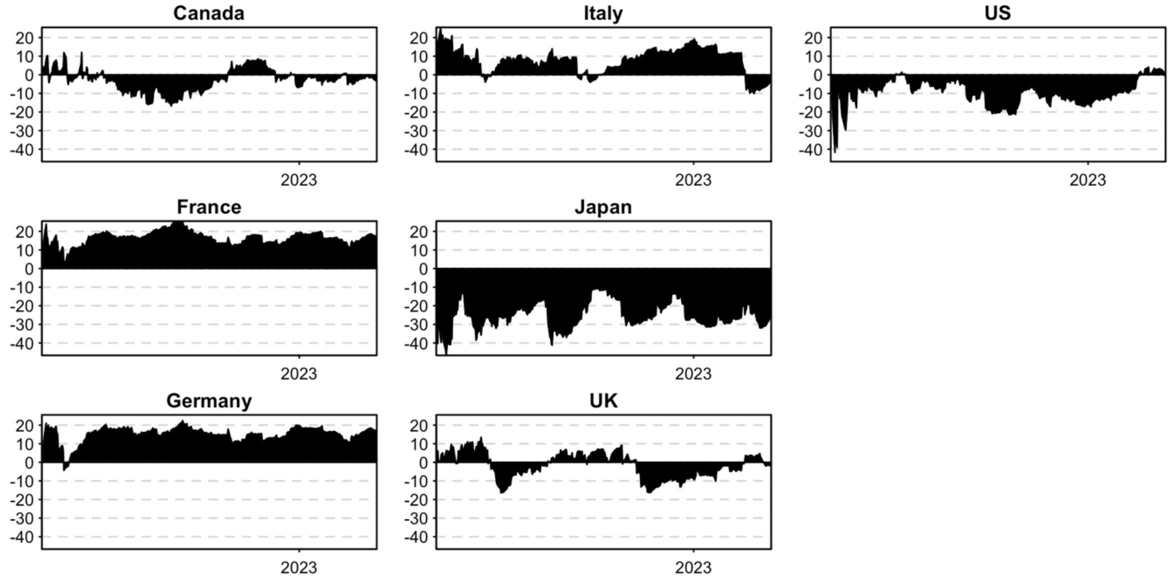
Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively. Results are based on the estimation following quantile Granger casualty test(Troster, 2018).

Table A.2: Quantile granger test results of fixed income assets to RUWESsent

τ	Canada	France	Germany	Italy	Japan	UK	US
0.05	0.41	0.51	0.25	0.53	0.55	0.32	0.34
0.10	0.51	0.28	0.23	0.44	0.90	0.44	0.40
0.15	0.44	0.46	0.15	0.63	0.68	0.43	0.98
0.20	0.75	0.52	0.23	0.76	0.83	0.31	1.08
0.25	0.80	0.53	0.25	0.81	1.15	0.42	1.15
0.30	0.89	0.57	0.19	0.87	1.62*	0.35	0.94
0.35	0.89	0.53	0.12	0.74	1.5*	0.43	0.76
0.40	0.99	0.62	0.10	0.91	1.43*	0.52	0.74
0.45	1.11	0.44	0.13	0.87	1.46*	0.63	0.65
0.50	0.94	0.42	0.14	0.85	1.31*	0.78	0.88
0.55	0.99	0.59	0.21	0.76	1.4*	0.84	0.95
0.60	0.66	0.50	0.13	0.93	1.28	0.60	1.05
0.65	0.56	0.33	0.33	1.01	0.86	0.78	1.04
0.70	0.50	0.76	0.30	0.85	0.93	0.90	1.24
0.75	0.48	0.90	0.46	0.76	0.67	0.71	1.29*
0.80	0.41	0.80	0.45	0.51	0.58	0.77	1.15
0.85	0.71	0.43	0.26	0.53	0.44	0.52	0.99
0.90	0.63	0.30	0.13	0.39	0.38	0.86	0.59
0.95	0.41	0.30	0.02	0.17	0.30	0.30	0.72

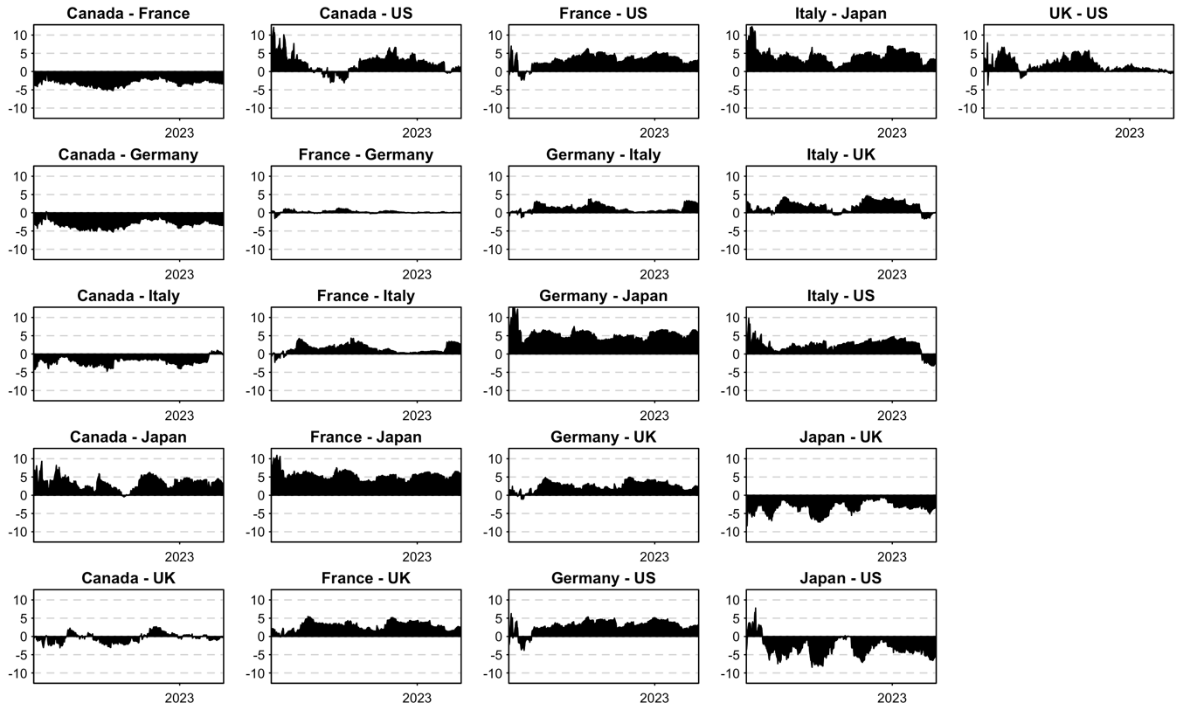
Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively. Results are based on the estimation following quantile Granger casualty test(Troster, 2018).

A3. Contagion across G7 debt market results



Notes: Results are based on a generalized forecast error variance decomposition with 10 steps in advance and a 22-day rolling-window TVP-VAR model with a lag length of order 1 (BIC).

Figure A.2: Dynamic net directional connectedness



Notes: Results are based on a generalized forecast error variance decomposition with 10 steps in advance and a 22-day rolling-window TVP-VAR model with a lag length of order 1 (BIC).

Figure A.3: Dynamic net pairwise directional connectedness

Table A.3: Additional robustness test: Impact of CMDI on corporate bonds

	(1)	(2)	(3)	(4)	(5)
Variables	US_IGCB	UK_IGCB	Japan_IGCB	EUROZONE_IGCB	Canada_IGCB
CMDI	-0.143***	-0.299***	-0.213***	-0.216***	-0.124***
	(0.019)	(0.040)	(0.023)	(0.027)	(0.017)
Constant	0.010	0.028*	0.016*	0.017*	0.008
	(0.007)	(0.016)	(0.008)	(0.010)	(0.006)
Observations	66	66	66	66	66
R-squared	0.466	0.466	0.609	0.524	0.461
Adjusted R-squared	0.457	0.457	0.602	0.516	0.452

Note: This table presents the results of the impact of CMDI on G7 corporate bonds. All models are estimated using the Newey–West OLS estimator. Robust standard errors are in parentheses. ***,**,* denote significance at 1%, 5% and 10% significance level.