Mathematical Modelling and Numerical Simulation with Applications, 2024, 4(4), 395–415

https://dergipark.org.tr/en/pub/mmnsa
ISSN Online: 2791-8564 / Open Access
https://doi.org/10.53391/mmnsa.1455355

RESEARCH PAPER

Investigating Türkiye's financial nexus: A wavelet coherence analysis of sovereign CDS spreads, bond yields, stock index, and FX rates

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Abstract

This article investigates the intricate relationships between sovereign credit default swaps (CDS) and various Turkish financial assets, including the US Dollar to Turkish Lira exchange rate (USDTRY), the Borsa Istanbul 100 (XU100) stock index, and government bond yields. Employing a rigorous wavelet coherence analysis that captures the timefrequency domain, this study utilizes daily data from November 2008 to July 2022 period containing important financial, economic and global health crises, such as Great Recession, European Debt Crises, and COVID-19 pandemic. The wavelet coherence results uncover that the causality between variables is contingent on both the frequency domain and evolves dynamically over time, with the most significant interdependencies manifesting in the medium term. Moreover, the analysis reveals that government bond yields, and their respective volatilities positively impact CDS spread and its volatility. Similarly, the USDTRY rate leads to positive changes in the CDS spread. By contrast, the volatility of CDS spreads positively influences foreign exchange volatility and the XU100 index volatility. The CDS spread negatively affects the XU100 index. Overall, the findings elucidate the direction of causality between Turkish CDS spread and retained Turkish financial assets and then provide valuable information on the predictive power of those securities for investors, financial risk managers, and policymakers.

Keywords: Credit default swap; time-series models; asset pricing; wavelet coherence analysis

AMS 2020 Classification: 91B82; 91B84; 91G70; 91G30; 62P05

1 Introduction

The nexus between CDS spread and financial assets is paramount for financial agents, including portfolio managers, financial risk managers, and policymakers. In terms of securities, a portfolio

➤ **Received:** 19.03.2024 ➤ **Revised:** 06.10.2024 ➤ **Accepted:** 21.10.2024 ➤ **Published:** 30.12.2024

is a collection of at least two securities designed to lower risk and achieve the highest possible return for the expected risk. Investors aim to create the best mix of investments with the lowest risk level while maximizing their expected returns. For these purposes, CDS is considered a financial instrument and a potential portfolio component; comprehending its correlation with other financial assets displays a pivotal role in constructing efficient portfolios, as per the seminal work of the Markowitz model. CDS also serves as a crucial indicator of credit and country risk and may be a great predictor of the dynamics of financial assets, encompassing returns and volatility [1]. Indeed, the higher the CDS spread ordinarily leads to the higher the cost of borrowing (interest rates) and the higher the risk of default. Additionally, rising sovereign risk attributed to political and economic instability prompts investors to divest from assets and repatriate funds, thereby exerting downward pressure on the country's security prices and currency. Conversely, the return and volatility of financial assets can also offer insights into the dynamics of CDS spreads [2]. In summary, a bidirectional relationship between CDS and financial assets may exist, determining the crucial need to discern these relationships and causalities.

The empirical exploration of the relationship between CDS spread and financial assets has captivated the attention of numerous researchers. Findings from these investigations have unveiled that the CDS-finance series link hinges upon various factors: the nature of the financial asset (e.g., currency exchange, stock index, or interest rate), the type of CDS (sovereign or corporate/firm specific/sectoral), the frequency of retained series (daily, or weekly or monthly), the retained period, and the applied method. Most extant studies have predominantly concentrated on corporate, firm-specific, or sectoral CDS, frequently utilizing regression or causality tests to probe the causality or relationship between the return of retained series.

This study contributes to the existing literature in three significant ways. Firstly, it responds to the pronounced volatility exhibited by Turkish CDS in recent years, a phenomenon that has gripped investors' attention due to its consequential role as a vital financial indicator. This study considers the possible interrelation between 5-year CDS spread and retained financial asset returns and volatility. It scrutinizes the impacts of the CDS spread volatilities, whereas prior research focused mainly on the relationship between CDS spread and financial asset returns. The interconnectedness between returns and volatility is particularly germane due to the influence of leverage effects, wherein returns can significantly affect volatility and vice versa as a fallback effect. These considerations are critical for financial actors, portfolio managers, and risk managers. Secondly, this study pays meticulous attention to investors' investment horizons. Theoretically and empirically, it is well-established that short-term and long-term investors, such as day-to-day traders and fund managers, respond differently to market dynamics. Most of the existing studies did not account for the divergence in investment horizons [3–6]. Apart from the frequency domain, it has been shown by several authors that the relationship between financial assets changes through time [7–10]. The relationship between financial series evolves through time and frequency, a facet addressed through dynamic connectedness models and wavelet coherence analysis (WTC). Compared to the former, WTC offers the advantage of not requiring linearity and stationary assumptions and affords continuous frequencies. In contrast, connectedness models necessitate predefined frequency bands. Thus, WTC is employed in this study to examine the lead-lag connections between CDS spreads and financial assets at different frequencies and over varying periods.

This study's third significant contribution consists of investigating the relationship between the CDS and three Turkish financial assets: USDTRY, XU100, and 2-year bond yields. Almost all existing studies looked at the relationship between the CDS spread and one individual financial asset. For example, [11] studied the relationship between CDS and stock indices, [12] examined CDS and bonds, and [13] focused on CDS and exchange rates. Furthermore, only a few authors

investigated the relationship between Turkish CDS and Turkish financial series [14–21]. These existing studies either considered only the relationship between the CDS spread and one Turkish financial asset, and/or considered only the relationship between CDS spread and financial return or level.

In sum, we contribute to the existing empirical literature in three ways by investigating the relationships between the Turkish 5-year CDS spread and 3 financial assets (USDTRY, XU100, and 2-year bond yields). The relationships between volatilities, between returns, and between return and volatility are analyzed. These investigations are done by using daily data covering a long period and Wavelet Coherence analysis which enables to account for time and frequency domains.

The remainder of the paper unfolds as follows. Chapter two comprehensively reviews the extant literature concerning the relationship between CDS spreads and bond yield/price/ interest rate, currency exchange rates, and stock indices. Chapter three delineates the data sources and methodology employed. Empirical findings derived from WTC are presented and discussed in the fourth chapter, ultimately stating the concluding remarks in the final chapter.

2 Literature review

Relation between CDS and bond price/yield/interest rate

Within the ambit of the literature review, it becomes abundantly clear that the connection between sovereign CDS and bond metrics such as yield, yield spreads, and bond prices is by no means uniform. Instead, the relationship in question is dynamic and influenced by several key factors. This includes analyzing the specific characteristics of the sovereign entity, determining whether it is a developed [22] or developing country [23], ensuring the stability of the observation periods over time, and collecting data daily [24], weekly [25], or monthly [2]. Additionally, the choice of econometric modeling used for the analysis also plays a significant role. The literature categorizes empirical studies into three groups based on the datasets used: cross-sectional, time-series, and panel data analysis. Several cross-sectional studies utilized the VAR method [26–29] and the VECM method [30–32]. Panel data analysis combines time and cross-sectional dimensions and offers comprehensive insights but may have limitations in forecasting the impact of financial indicators on macroeconomic variables. Noteworthy studies in panel regression include [33] with their panel VAR analysis and [34] with the panel VECM method. In time-series analysis, GARCHand wavelet-based methods are prominent. Notable studies in GARCH methodology include [35] with multivariate GARCH, [36] with EGARCH, and VAR-BEKK-GARCH analysis by [37]. Contemporary studies have emphasized wavelet-based methodology [15, 18, 38].

The country's political, economic, and social developments play a significant role in shaping the trajectory of CDS spreads. Adverse developments in these spheres precipitate tangible economic and financial performance metrics erosion. Consequentially, this escalation in risk triggers an amplification in the sovereign's risk premium, subsequently manifesting as an upswing in CDS spreads. This, in turn, carries far-reaching implications, extending its influence on interest rates. As elucidated by [22], the ascent of CDS spreads invariably exerts upward pressure on borrowing costs for the sovereign entity, thereby inexorably influencing the prevailing interest rates, which is most conspicuous in the context of 10 European countries from 2006 to 2010 by using VECM method. In addition to that, [4] presented that CDS spreads lead interest rates in France, Italy and Türkiye in their VAR analysis results.

Conversely, [39] stated an intriguing perspective, suggesting that increased CDS spreads could be associated with reduced bond yields and T-bills. Specifically, investors may perceive long-term bonds as a sanctuary of safety when CDS spreads increase. This shift in perception triggers an upsurge in demand for bonds and T-bills, effectively exerting downward pressure on the interest

rates attributed to these financial instruments. This phenomenon, primarily experienced in developed economies such as Germany, the U.S., and the U.K., presents a significant intercorrelation between risk perception and fixed-income securities.

Moreover, [40] adds depth to the understanding in the literature by unveiling an array of factors, extending beyond public debt levels and anticipated inflation rates, that hold an impact on the sovereign interest rate spread within emerging economies. In essence, bond interest rates serve as an indicator of risk premiums, and when interest rates increase in tandem with the augmented perception of risk, CDS spreads concurrently elevate. For emerging economies like Türkiye, which rely on external capital inflows to fuel their economic progress, this reliance on foreign investment amplifies their susceptibility to credit risk during political or economic upheavals. This vulnerability, in turn, triggers capital outflows from domestic markets, thereby further accentuating Türkiye's risk profile.

Numerous authors have examined the relationship between sovereign CDS and bond markets. However, the outcomes of these investigations exhibit substantial heterogeneity, primarily contingent upon the specific datasets and periods employed in their analyses. For instance, [30] investigated the connectivity of eight sovereign CDS markets in developing countries with corresponding bond markets using weekly yield spreads on sovereign bonds. According to the Vector Error Correction Model (VECM) results, the CDS market exerted no price impact on bond yields between 1999 and 2002. In contrast, utilizing a VECM model as well, [31] found that daily Greek sovereign CDS and bond markets are cointegrated, with CDS having a significant impact on price discovery over the long term. In a different vein, [29] identified bond spreads as the predominant factor explaining CDS premiums, their analysis encompassing daily data from 2011 to 2018 and employing VAR and VECM models. [12] examined the relationship between CDS premia, 5-year bonds, the German Bund for the EU, gilts for the UK, and the US Treasury bond for the rest using panel cointegration and panel unit-root tests. Their extensive dataset covered 18 sovereign bond issuers as core, peripheral, and developing countries, along with 17 financial corporations, spanning the period from 2006 to 2009. Remarkably, their findings established the existence of long-run parity between CDS and bond spreads, with distinct leadership roles emerging in different regions: the bond market leads in core countries. In contrast, CDS markets played a more prominent role in peripheral and developing countries.

[3] examined the link between daily CDS premiums and government bond spreads of France, Italy, Greece, Spain, Portugal, and Ireland during the EU Debt Crisis of 2009–2011. Their results aligned with the prior literature, revealing that Granger causality tests indicated that government bonds lead the price discovery process for France and Italy. CDS markets have a leading role for Greece and Spain, whereas there is a bidirectional causality for Portugal and Ireland. In three economically unstable countries, namely Brazil, South Africa, and Türkiye, [41] explored the link between sovereign credit risk premium (log sovereign CDS), sovereign bonds, and currency rates over the period ranging from February 2007 to January 2017. For this investigation, the authors used a variety of methodologies, such as cointegration and causality methods. The Todo Yamamoto Causality test results suggested bidirectional causality between the CDS spreads and the Turkish and Brazilian exchange rates and interest rates. However, in South Africa, the causation between CDS and exchange rate and interest rate was unidirectional, with the exchange rate and interest rate causing the CDS spreads.

In contrast to earlier studies, several authors used firm-specific or sector-specific data to examine the relationship between CDS spread and bonds [42]. Most of these studies showed the impact of corporate CDS spreads on the corporate bond market. For example, [43] used the VAR model to examine the co-movement of single-name CDS spread; bond spread changes, and stock returns of 58 individual firms from 2000 to 2002 at the aggregate and firm-specific levels. The authors' analy-

sis used US and non-US reference entities and monthly, weekly, and daily data frequencies. They found that CDS spread fluctuations Granger trigger bond spread changes for more enterprises with higher data frequencies than vice versa. An accompanying VECM model and a cointegration study of CDS and bond spreads demonstrate that the CDS market predominantly drives price discovery. Its stock return also influences the variations in each company's CDS and bond spreads.

Relation between CDS and currency exchange

Theoretical and empirical literature studied the relationship between CDS and currency exchange by imposing or analyzing the direction of causality between those variables. In particular, several studies investigated the impact of CDS on currency exchange rates. Conversely, the currency exchange rate was considered a CDS level or spread determinant. In addition, some researchers explored the association between CDS and currency exchange without imposing any direction of effect.

Unidirectional impact between CDS and currency exchange

Several authors have, theoretically and empirically, shed light on the impact of sovereign CDS on currency exchange by indicating that sovereign defaults can lead to currency attacks or depreciation [44]. Investors would also sell equities already denominated in the country's currency and repatriate funds due to higher country risk brought on by political and economic turmoil, which would put downward pressure on the currency [45]. Empirical evidence substantiates the notion that emerging economies, which heavily rely on foreign capital inflows for their economic substance, are particularly susceptible to the influence of CDS on currency exchange rates [2, 6]. Such economies become vulnerable to credit risk during periods of political or economic downturn. Consequently, interest rates tend to rise concurrently with expanding CDS spreads, exacerbating the situation through capital flight and heightened domestic market risk perception. These dynamics can set a downward spiral within the economy and lead to pronounced currency volatility in foreign exchange markets.

Contrarily, an alternative perspective posits currency exchange rates as determinants of CDS spreads. In a study conducted by [2], which performed a panel regression to model CDS term premia changes, several explanatory variables were considered, including U.S. stock returns, changes in the U.S. variance risk premium, and U.S. long-term bond yields; domestic stock returns denominated in domestic currency; currency returns; and percentage changes in the dollar value of sovereign foreign currency holdings. This comprehensive analysis encompassed data from 29 countries from December 2007 to June 2017. This research revealed a contemporaneous positive relationship between changes in CDS term premia and domestic stock returns, currency appreciation, and the expansion of FX reserves. This insight highlights the intricate feedback loops between currency dynamics and sovereign credit risk, adding depth to our understanding of financial market interactions.

Interrelation between CDS and currency exchange

Compared to previously cited studies, some authors [46, 47] opted to explore the interrelation between sovereign CDS and currency exchange without imposing any direction of causality. Notably, the findings stemming from these analyses exhibit a certain degree of heterogeneity. The direction and magnitude of the interaction between sovereign CDS and currency exchange depends on a variety of factors, including the specific measure of exchange rates employed, the size of the net foreign currency exposure of an economy, the investment horizon, the period, and the used model/method, among other factors determined the empirical results in those studies [6, 14, 45].

[6] examined the causal link between exchange rate and sovereign risk as CDS spread by using data from October 2004 to December 2016 from 16 emerging economies and employing a structural vector autoregressive model (SVAR). Their findings revealed that the direction and amount of sovereign risk reactions to FX rate variations depend on the exchange rate measure employed and the degree of an economy's net foreign currency exposure. A decline in the domestic currency's value in relation to the US dollar causes a rise in sovereign risk. In contrast, a decline in the effective exchange rate has only a minor effect on the sovereign risk in countries where the private sector has a significant negative net foreign currency exposure.

[14] examined the relationship between sovereign CDS and Euro/Turkish Lira currency exchange using monthly data from September 2009 to October 2015 and various causality tests, including asymmetric causality test, frequency domain causality test, Bootstrap Rolling Window Causality test, and the MS-VAR model. While the short-term causality runs from the nominal exchange rate to the CDS differential, the long-term frequency domain causality test revealed bidirectional causation between the CDS differential and the exchange rate. Additionally, a change in the CDS differential would eventually lead to exchange rate volatility. Correspondingly, the rolling windows causality test demonstrated that Türkiye's nominal EURTRY exchange rate is not primarily determined by the CDS differential, with the causation linkage manifesting for just two months. The test findings revealed that the causation linkage existed for two months, in December 2013 and January 2015.

In order to analyze the connection between sovereign CDS spreads and exchange rates in developed economies, including the US, Japan, Switzerland, and the Eurozone, [45] utilized a bivariate VECM model with random coefficients. According to their research, these developed economies' relative sovereign credit risk affects market expectations for their currency rates over the long term. However, they noted that in the short term, this influence is drastically altered during times of crisis, leading to substantial and enduring price deviations from their long-run equilibrium amid monetary policy actions taken by central banks and market volatility.

Interrelation between CDS and stock index

The Merton-type structural model presents the theoretical correlation between CDS and the stock market. Expanding this structural model to sovereign issuers suggests a negative correlation between government CDS spreads and stock prices [24]. The country's political, economic, and social changes directly tie to CDS. Negative developments in these areas cause a deterioration in economic and financial indicators, an increase in the country's risk premium, and, as a result, an increase in CDS spreads. International investors may abandon the stock markets as CDS spreads rise, causing a decrease in asset prices and liquidity issues [48].

Most existing studies investigating the relationship between Credit Default Swaps (CDS) and stock markets have focused primarily on firmspecific, corporate, or sectoral CDS, often overlooking broader market influences. Researchers have found inconclusive results regarding which market, stock, or CDS leads or lags in the lead-lag relationship. Most of this research shows that equities and stock markets cause firm-specific, corporate, and sectoral CDS. Several studies demonstrated a significant causal relationship between equity and corporate CDS [49–51].

Instead of firm-specific/corporate/sectoral CDS, some authors analyzed the interrelation between sovereign CDS and stock markets. [52] reached opposing results in their study on the lead-lag relationship between stock indexes and sovereign CDS. For this investigation, these authors used data from 15 countries (including the U.S. and European countries) from 2004 to 2016 and employed a rolling VAR framework. They discovered that stock market returns predict sovereign CDS returns and sovereign CDSs anticipate equity return conditional volatility. The degree of

connectivity observed fluctuates over time and is directly associated with financial crises. Causality occurs exclusively during challenging economic periods in all countries; however, it is also evident in several Eurozone countries post-crisis.
Similarly, information transfer is more intensive in the U.S. than in Europe for the return model, while the opposite result is valid for the volatility model. Both research show more causalities in the Eurozone than in non- Eurozone countries. There are also some differences between Euro-core and Euro-peripheral countries, depending on the sub-period examined. For instance, they found significant causal relationships between sovereign CDS returns and stock returns during the sovereign debt crisis in the europeripheral countries that were most affected. From January 2001 to February 2007, [24] studied the dynamic relationship between sovereign CDS spreads and stock prices for seven Asian countries. For most Asian countries, they found a significant negative correlation between the CDS spread and the stock index. They have discovered a long-run equilibrium pricing relationship for China, Korea, and Thailand. Other countries' limited integration may be due to market frictions and model applicability. They employed the VECM model and Hasbrouck-bound tests established by [53] with [54] tests to evaluate price discovery. Their research revealed that CDS markets dominate in the five countries investigated. The stock market impacts two countries, yet only one dominates price discovery. Equity investors should thus monitor the CDS market for additional input.
Empirical research on the relationship between CDS and the stock market in terms of volatility is scarce, with most studies focusing on the US corporate market [51, 55, 56]. These studies indicated the leading role of CDSs over stocks. In [57] study, early findings revealed a connection between CDS and the stock market regarding returns and volatility. Byström identified a negative correlation between CDS spreads and stock prices, alongside a positive correlation between CDS spreads and stock market volatility with data from European sectoral iTraxx CDS indexes spanning 2004 to 2005.

3 Data and methodology

Most of existing studies investigating the relationship between the CDS spread and financial series used mainly static Granger causality tests [3, 46, 47] and/or static vector autoregressive (VAR) [26–29] or static vector error correction model (VECM) [30–32]. These models require stationary series and assume that the relationship between series is linear. Furthermore, the classical form of these models assumes that the relationship between series is stable through the retained period. Some empirical studies showed that the relationships between financial assets change over time [7–10]. The interdependencies and correlations among assets can also vary depending on the investment horizon, which refers to the frequency [58–60]. Different types of investors operate with different investment horizons. Active investors and day traders typically focus on short-term investments, which can range from hours to days. On the other hand, insurance companies, pension funds, and passive investors prioritize medium- to long-term investments, which can span from several weeks to years.
The time-frequency domain can be taken into account by the dynamic connectedness model, proposed by [61, 62], and the wavelet coherence analysis. Unlike the connectedness model, Wavelet coherence analysis does not require the conditions of linearity and stationarity. Additionally, the wavelet presents the frequency domain as continuous, in contrast to the connectedness model, which requires users to specify fixed frequency bands. Furthermore, the connectedness model of the lead/lag relation between retained series, whereas Wavelet enables us to determine the lead/lag relations as well as the correlation between assets at different frequencies through time. For these reasons, Wavelet Coherence analysis is used in this article.
Several authors used methods based on wavelet analysis to investigate the connectedness/correlation

between assets at different frequencies over time [51, 58, 63].

Data

This paper analyzed the interrelation between Turkish 5-year sovereign CDS (in US dollars), the XU100 stock index (XU100), the currency exchange \$/TL (USDTRY), and the 2-year government bond yield (2yBY). It is important to note that the Türkiye CDS 5-year USD, rather than EURO, was considered in order to analyze its effect on USDTRY.

The rapid increase in Türkiye's CDS premium started on November 8, 2021, and continued until July 11, 2022. This trend caught the attention of both domestic and foreign experts and investors, leading to the research discussed in this article. As being an important emerging country due to its geographical and economic position, this study considers Türkiye's CDS premium spread's impacts on several economic and financial variables and investigates five hypotheses:

H_1: There is a significant relationship between 5-year CDS spread and retained financial asset returns.

H_2: There is a significant relationship between the volatility of 5-year CDS spread and the volatility of retained financial asset returns.

H_3: There is a significant relationship between the 5-year CDS spread and the volatility of retained financial asset returns.

H_4: There is a significant relationship between the volatility of 5-year CDS spread and retained financial asset returns.

H_5: All these relationships mentioned above (H1:H4) are time and frequency dependent.

These investigations used daily data from 10 November 2008 to 29 July 2022. Thus, the sample encompasses a period marked by financial/economic stability and instability Great Recession, European Debt Crises, and COVID-19 pandemic. The volatility of the retained series corresponds to the 21-day standard deviation of each series.

Wavelet coherence analysis (WTC)

Wavelet analysis allows one to extract the periodic variation of a variable's frequency content [64]. The continuous wavelet transform of a series $x(t)$ is defined as:

$$W_x(\tau, s) = \frac{1}{\sqrt{s}} \sum_{t=1}^{N} x(t) \varphi^* \left(\frac{t-\tau}{s} \right), \tag{1}$$

where $*$ indicates complex conjugate, φ is Morlet wavelet, s is the scale parameter, which is the frequency in this domain, and τ the transformation parameter. In this article, we employed the Morlet wavelet function, which provides information on the local phase and is impactful in economic and financial analyses. Morlet wavelets [65] are expressed as,

$$\varphi(\eta) = \pi^{-1/4} e^{i w_0 \eta} e^{1/2 \eta^2}, \tag{2}$$

where η represents the time, and w_0 is frequency chosen 6 because it offers a strong match among frequency and time domain [66]. The purpose of the CWT is to use the time series as a band pass filter after applying the wavelet. The wavelet power that measures the variability in the time series both in time and in frequency is defined as $W_n^X(s)$. The synchronization (relation/correlation) between two-time series can be measured with the coherence between them.

The wavelet coherence between two time series is defined as:

$$R_n^2(s) = \frac{|S(s^{-1}\Psi_n^{XY}(s)|^2}{S(s^{-1}|W_n^X(s)|^2).S(s^{-1}|W_n^Y(s)|^2)}, \tag{3}$$

where S is the smoothing operator, and s is a wavelet scale. The crosswavelet power spectrum, $\Psi_n^{XY}(s)$ is expressed as:

$$\Psi_n^{XY}(s) = W_n^X(s).W_n^{Y*}(s), \tag{4}$$

where, $W_n^{Y*}(s)$ represents the complex conjugate of $W_n^Y(s)$. As for $W_n^X(s)$ and $W_n^Y(s)$ they represent the wavelet transforms of X and Y, respectively.
The graphical representation of wavelet coherence provides information on the correlation between the retained paired observations. The wavelet coherence plots show high to low levels of coherence for a specific time if the retained series are correlated, and these areas are colored from red to blue. Finding the phase difference between the two series will reveal their lead-lag connection. One definition of the phase difference with X and Y is:

$$\varphi_{xy}(u,s) = tan^{-1}\left(\frac{I\{S((s^{-1}\Psi_n^{XY}(u,s)))\}}{R\{S((s^{-1}\Psi_n^{XY}(u,s)))\}}\right), \quad \varphi_{xy} \in [-\pi,\pi]), \tag{5}$$

where R and I stand for the power spectrum's actual and imaginary parts, respectively. Phase differences across series show how they co-move at various scales. If the arrows point to the right (left), the time series are comoved, so in phase (anti-phase). If arrows move up (phase difference on $[0,\pi/2]$), second lead first. If arrows move down (phase difference on $[0,-\pi/2]$), then the first leading.

4 Empirical results

CDS spread & 2-year bond yield (2yBY)

The empirical results obtained from the analysis consistently depict a predominantly positive relationship, particularly evident in the mediumterm context concerning the CDS-2yBY dynamics. To clarify, as shown in Figure 1, the directional arrows point right and upwards, indicating a positive impact of 2yBY on the CDS spread at medium-term horizons, spanning 64 to 256 days. Furthermore, a comparable pattern emerges over a more extended timeframe, specifically within the initial segment of the studied period, from November 2008 to 2018. A positive correlation between CDS-2yBY is discernible during this period, especially in the medium-term scales from 256 to 1024 days. Additionally, positive relationships between CDS-2yBY surface during certain short-term intervals, encompassing scales of 16 to 64 days. These shorter-term positive associations can be attributed to either the favorable impact of CDS on 2yBY during specific brief intervals, as exemplified by the dynamics observed in March 2020, or conversely, the constructive influence of 2yBY on the CDS during similarly short-lived periods.
Parallel insights emerge from examining the interplay between the volatility of CDS spread and the volatility of 2yBY, as illustrated in Figure 2. Here, the directional arrows again signify a positive influence, predominantly manifesting in the medium-term realm, spanning scales of 64 to 256 days. In these contexts, the volatility of 2yBY significantly impacts the volatility of the CDS spread. Conversely, in the short-term domain, instances arise where the volatility of CDS spread positively influences the volatility of 2yBY. However, this phenomenon is infrequent and primarily characterizes very brief time intervals.

Contrary to these previous results, a positive relationship between the volatility of the CDS spread and the volatility of 2-year bond yield can be observed during the first part of the COVID-19 pandemic at the short and medium terms (Figure 2) . Arrows pointing right down indicate a positive impact of the volatility of CDS spread on the volatility 2yBY. In the same line, the 5-year CDS spread has a positive impact on the 2yBY during the first month of Covid-19 at short-run (Figure 1). The relationship between the volatility of CDS spreads and the 2yBY, in a broad

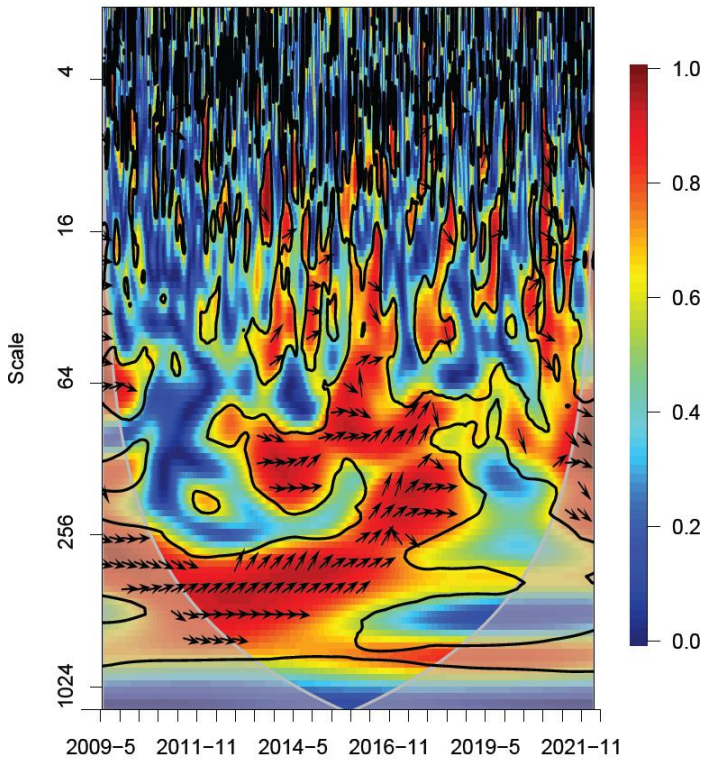

Figure 1. WTC between CDS and 2yBY

statistical sense, does not exhibit a significant connection, with exceptions being sporadic and mainly manifesting during select short-term intervals, as depicted in Figure 3. Notably, instances of a positive relationship between the volatility of CDS spreads and the 2yBY are discernible around 2017-2019 in the medium-term context. The directional arrows pointing right in this graph signify this positive association, indicating that during these periods, the volatility of the CDS spread had a constructive impact on the 2yBY. Conversely, during the earlier years considered in the analysis, the right-up arrows signify that the 2yBY positively influenced the volatility of CDS spreads.

Turning attention to the connection between the volatility of 2yBY and the CDS spread, there is a similar pattern of a general lack of statistical significance, punctuated by some isolated periods and frequencies when meaningful relationships emerge, as illustrated in Figure 4. In particular, a notable positive relationship emerges in the medium-term horizon (scales 64-256) over 2017-2019, primarily driven by the influence of 2yBY volatility on the CDS spread. This finding is consistent with the earlier observation of the positive impact of 2yBY volatility on the volatility of CDS spreads in the medium term, as depicted in Figure 2. Furthermore, one can observe positive relationships in shorter-term contexts during specific, albeit brief, intervals, such as at the onset of the COVID-19 pandemic which aligns with the findings of [67]. Conversely, at longer-term horizons, as indicated by the right-down arrows, a positive impact of the CDS spread on the

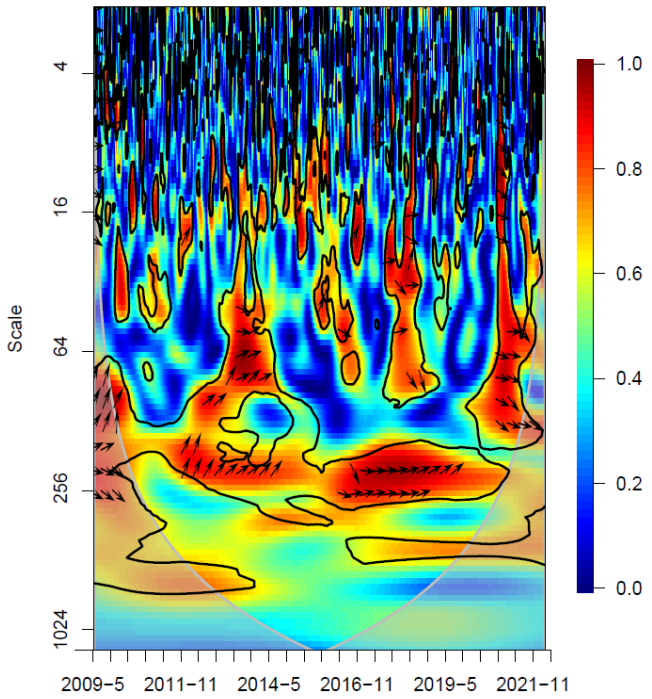

Figure 2. WTC between the volatility of both CDS and 2yBY

volatility of 2yBY persists consistently throughout the analyzed period.

In summary, this study indicates that the 2-year government bond yield (and its volatility) positively impacts the 5-year sovereign CDS spread (and its volatility) within the medium-term horizon. However, it is crucial to note that these relationships are not uniform across different timeframes, and statistical significance is observed only during specific short-term intervals. These findings diverge from the outcomes of previous empirical studies [22, 31, 39], possibly owing to differences in the models/methodologies employed and the chosen study periods. Notably, earlier research did not delve into the frequency domain, whereas our analysis highlights that the interplay between these financial series varies depending on the investment horizon. A plausible explanation for our findings is that higher bond yields, signifying increased borrowing costs, place a greater fiscal burden on the government or treasury, elevating default probabilities and subsequently positively impacting CDS spreads. Our finding can also be explained by the fact that bond interest rates serve as an indicator of risk premiums, and when interest rates increase in tandem with the augmented perception of risk, CDS spreads concurrently elevate [40].

By contrast, a significant impact of the CDS spread on the 2yBY can be observed at short-run during the first months of COVID-19. Similarly, the volatility of the CDS spread impacted positively the volatility of the 2Yby at short-run during the first month of the COVID-19 pandemic.

CDS & USDTRY rate

This analysis reveals a generally positive relationship between CDS and foreign exchange rates (FX), particularly within the medium-term and early long-term timeframes, spanning scales of 16 to 500 days, as depicted in Figure 5. This predominant positive association primarily resulted occasionally from the constructive impact of FX on CDS spreads, as indicated by directional arrows pointing right and upwards. However, it is noteworthy that occasional brief moments during this period also exhibit a positive connection attributed to the influence of CDS spreads on FX. Additionally, we observe favorable relationships in the short run, albeit for extremely brief intervals, driven primarily by the positive impact of FX on CDS spreads, represented by arrows

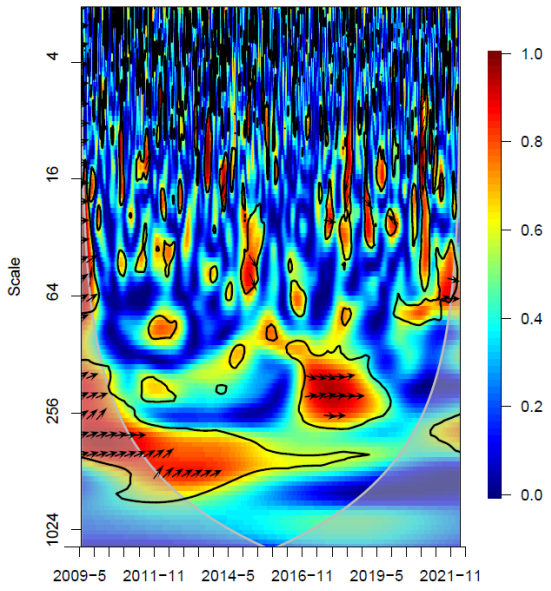

Figure 3. WTC between the volatility of CDS and 2yBY

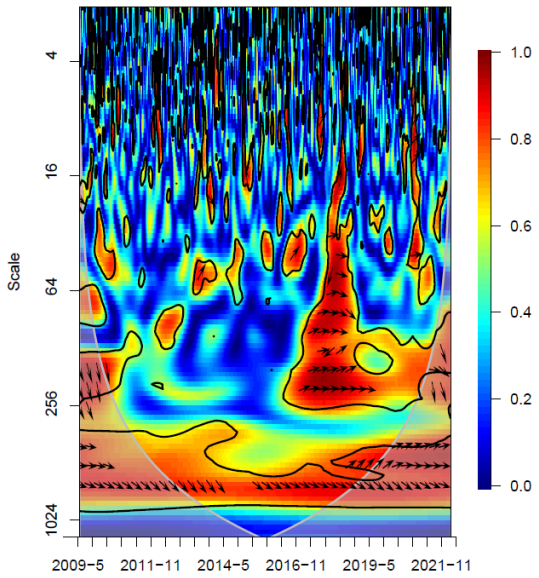

Figure 4. WTC between CDS and the volatility of 2yBY

pointing right and upwards and some.

Conversely, when examining the relationship between these financial indicators' volatilities, results underline a general lack of statistical significance. Nonetheless, exceptions to this pattern arise during specific periods and frequencies, as demonstrated in Figure 6. For instance, during the years 2017-2019, the positive impact on FX volatility in the medium term came from the volatility of CDS spreads. Similarly, positive relationships surface at shorter frequencies within select short-term intervals. These dynamics are a consequence of the volatility of CDS spreads influencing the volatility of FX during specific periods and, conversely, the volatility of FX impacting the volatility of CDS spreads during other periods. In the analysis, the relationship between the volatility of

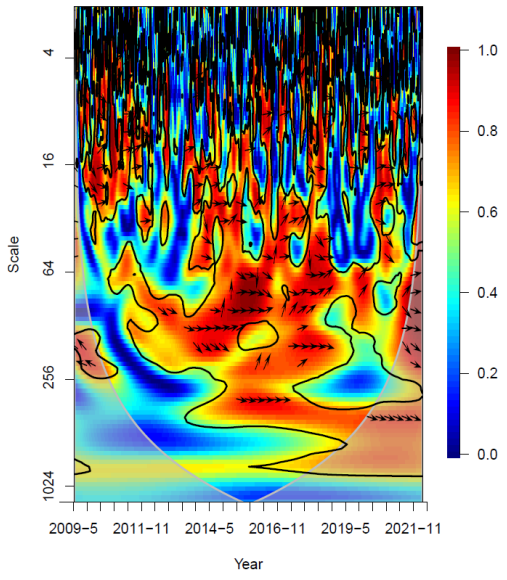

Figure 5. WTC between CDS and USDTRY

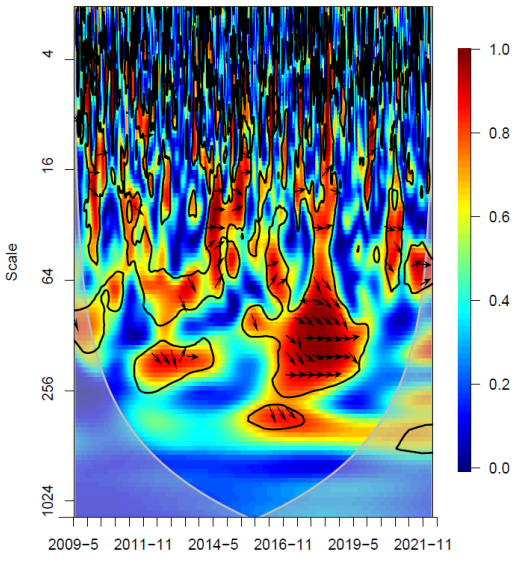

Figure 6. WTC between the volatility of both CDS and USDTRY

CDS spreads and the exchange rate ($/TL) is statistically insignificant, with exceptions arising

during specific periods and frequencies. Figure 7 illustrates that $/TL positively impacts the volatility of CDS spreads in the medium term, primarily within the scales of 150-250 days. Conversely, when we examine the relationship between the volatility of $/TL and CDS spreads, this relationship generally lacks statistical significance, except during specific intervals and frequencies, as demonstrated in Figure 8. Notably, a positive relationship emerged primarily in the medium and long term during the latter part of the 2010s, primarily due to the constructive influence of CDS spreads on the volatility of $/TL.

The findings underscore the nuanced relationship between $/TL and CDS spreads, contingent upon both the temporal and frequency domains. It becomes evident that, for the most part, FX positively impacts CDS spreads, particularly within the medium-term horizon. Additionally, we observe the significant interplay between the volatilities of these financial indicators, particularly between 2017 and 2019, where the medium-term FX volatility was notably influenced by the medium-term CDS spread volatility, albeit for very brief periods in the short term. This positive impact of $/TL on CDS spreads can be attributed to emerging economies, like Türkiye, needing borrowing in domestic and foreign currencies, with "hard" currencies such as the dollar playing a pivotal role. Consequently, any increase in currency exchange rates, which raises the cost of borrowing in "hard" currencies can positively influence the probability of default, thereby impacting CDS spreads. Furthermore, the depreciation of the domestic currency can also positively influence CDS spreads by adversely affecting the economic landscape. An increase in currency exchange rates can negatively impact the economic situation and increase the cost of borrowing in "hard" currency, contributing to an upward trajectory in CDS spreads. Regarding the relationship

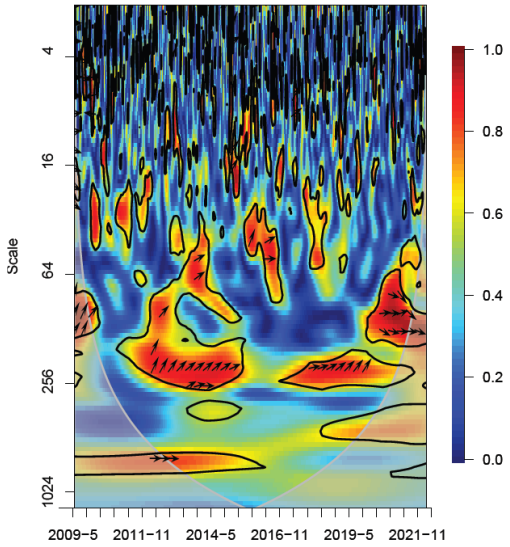

Figure 7. WTC between the volatility of CDS and USDTRY

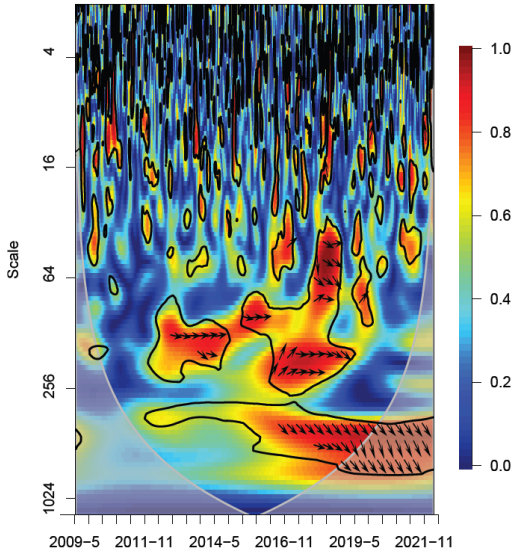

Figure 8. WTC between CDS and the volatility of USDTRY

between the CDS spread and USDTRY during the COVID-19 period, a positive relationship can be observed at short-run during the first months of COVID-19. The arrows are just pointing straight right without giving us no information on the direction of causality between the CDS spread and the USDTRY (Figure 5). A positive relationship can also be observed during the second part of COVID-19 at medium-run. Arrows are just pointing right toward the short run and pointing rightdown toward the long run indicating a positive impact of the CDS spread on the USDTRY (Figure 5). A positive impact of the volatility of USDTRY on the volatility of CDS spread can be observed at short run over very short period (Figure 6). By contrast, a positive impact of the

volatility of the CDS spread on the volatility of USDTRY can be observed during the medium run during the second part of the COVID-19 (Figure 6). In the same line, a positive impact of the volatility of the CDS spread on the USDTRY at medium run during the COVID-19 period can be observed (Figure 7).

CDS & XU100 return

The analysis reveals a dynamic relationship between 5-year Credit Default Swap (CDS) spreads and XU100 returns, which depends on both time and frequency domains, as illustrated in Figure 9 and Figure 10. Arrows pointing left and upwards in Figure 9 indicate that, for the most part, 5-year CDS spreads negatively influence XU100 returns within the medium-term horizon (between scales 64 and 256). This negative impact is also observed in the longer term during the initial portion of the study period, spanning from November 2008 to the first half of 2016. Similarly, the relationship between CDS spreads and XU100 returns is negatively significant during select short-term intervals. In terms of volatilities, Figure 10 demonstrates that the volatility of CDS spreads significantly impacts the volatility of XU100 returns in the medium term, denoted by right-down arrows. The graphical results suggest that fluctuations in CDS spreads positively affect the volatility of XU100 returns during these periods. Furthermore, when examining the relationship

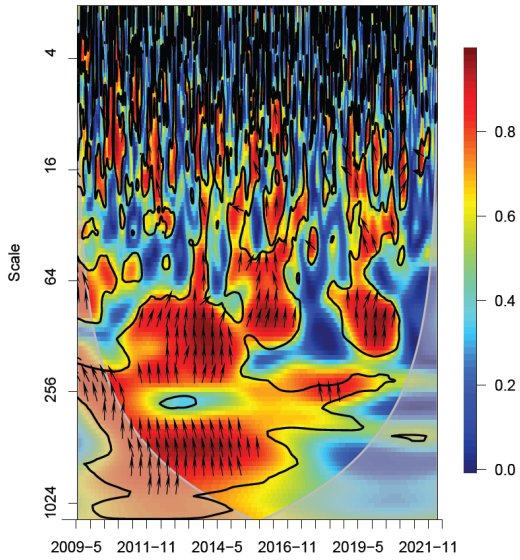

Figure 9. WTC between CDS and XU100

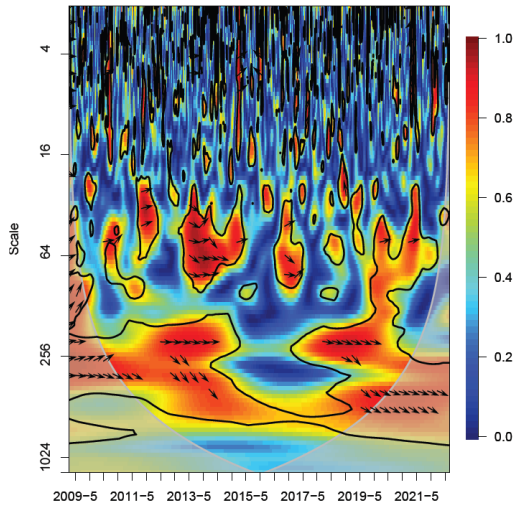

Figure 10. WTC between the volatility of both CDS and XU100

between the volatility of CDS spreads and BIST returns, as depicted in Figure 11 and Figure 12, the connections are generally insignificant, except during specific periods. Specifically, a significant negative impact of the 5-year CDS spread on XU100 returns is observed predominantly within the medium-term horizon. These findings align with the Merton-type structural model extended to sovereign issuers, which posits that rising sovereign CDS spreads can drive international investors away from stock markets, thereby decreasing asset prices and returns. Comparing our results with existing studies, some previous research indicates significant relationships between sovereign CDS and stock markets, primarily during instability or crises. This study's unique contribution lies in considering both the time and frequency domains, revealing the nuanced interplay between these financial variables, which can vary depending on the investment horizon.

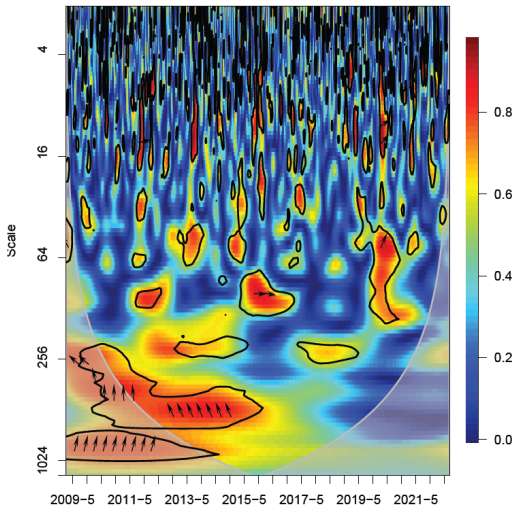

Figure 11. WTC between the volatility of CDS and XU100

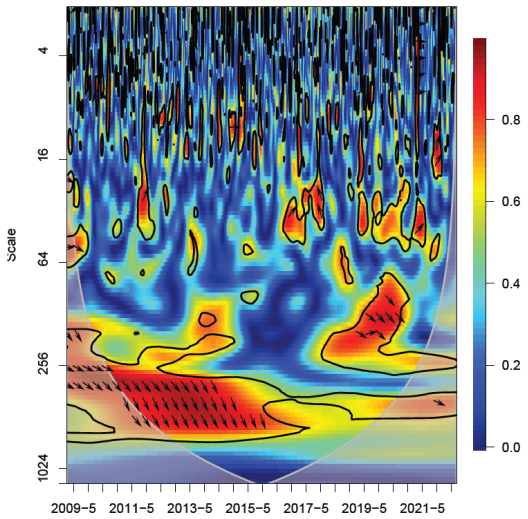

Figure 12. WTC between CDS and the volatility of XU100

5 Conclusion

This study investigated the relationship between the Turkish 5-year sovereign CDS spread and three Turkish financial assets (bond yield, $/TL currency exchange, and XU100 stock index). Unlike existing studies in the literature, we also analyzed the relationship between the volatility of the CDS spread and the volatility of retained three assets. The relationship between (the volatility of, respectively) the CDS spread and the volatility of (the return or rate of, respectively) retained three assets. The dataset of variables covers the daily data from 10 November 2008 to 29 July 2022; period covering stable and unstable periods, including the Great Recession, the European Debt Crisis, and the COVID-19 pandemic. For this investigation wavelet coherence analysis was used to account for the time and frequency domains.

According to our results, the relationship between CDS spread and the financial assets (bond yield, $/TL currency exchange, and XU100 stock index) are time and frequency domain dependent. Similar results were obtained for the relationships between volatilities and between volatilities and return. Notably, most statistically significant relationships emerged within the medium-term horizon, with short-term and long-term relationships generally lacking significance, except during specific short-term periods of instability. Thus, it becomes evident that both the temporal and frequency domains are crucial considerations when evaluating these financial dynamics. Although most existing studies consider the relationship between sovereign CDS and financial series as stable through time and frequency [3–6], there are few empirical studies accounting the time-frequency domain [15, 18, 68]. The latter authors found also that the relationships between sovereign CDS and financial series are time and frequency-dependent. These authors considered only the relationship between return or level and not the relationship between volatilities or between return and volatility.

Furthermore, our analysis reveals that the 2-year bond yield exerts a positive influence on the 5-year sovereign CDS spread, particularly within the medium-term timeframe. Similarly, the volatility of the 2-year bond yield emerges as a critical predictor of the volatility of the 5-year sovereign CDS spread, particularly within the medium-term horizon. A possible explanation for these findings is that higher bond yields, reflecting increased borrowing costs, impose a heavier fiscal burden on the government or treasury, raising default probabilities and, in turn, positively affecting CDS spreads. Another interpretation is that bond interest rates act as a signal of risk

premiums, and as these rates rise alongside heightened risk perception, CDS spreads increase accordingly [40]. Our findings contrast with those of earlier empirical studies [22, 31, 39], likely due to variations in the models/methodologies and data used and the time periods studied. Our findings are in line with results obtained by [15].

Similarly, the USDTRY exchange rate has a positive impact on the 5-year sovereign CDS spread, particularly within the medium-term timeframe. Conversely, the volatility of the CDS spread demonstrated a positive influence on the volatility of the FX rate during the years 2017-2019, as well as intermittently during short-term periods. These findings are opposite to the empirical findings or statements of some authors [2, 6, 44, 45]. These differences can be due to the difference in the used methods/models, data and considered period. However, some authors have obtained results consistent with our findings, such as [14] and [6]. For instance, [14] found quite similar results for the relationship between the Turkish CDS and the Euro/Turkish Lira exchange rate.

Our findings confirm that the rising trend in sovereign CDS spreads drives investors away from stock markets, decreasing asset prices and returns. This finding is in line with the theoretical expectation derived from the extension of the Merton-type structural model to sovereign issuers; which implies a negative correlation between government CDS spreads and stock prices [24]. This negative impact can be explained by the fact that an adverse development in the economic and/or financial situation of a country leads to an increase in the country's risk premium, and consequently, a rise in CDS spreads. As CDS spreads climb, international investors may exit stock markets, resulting in lower asset prices and liquidity challenges [48].

During the COVID-19 period, a significant impact of (volatility of, respectively) the CDS spread on the (volatility of, respectively) 2yBY can be observed at short-run during the first months of the COVID-19. In the same line, a positive impact of the volatility of the CDS spread on the USDTRY rate and its volatility can be observed during the medium run during the second part of the COVID-19. Conversely, a positive impact of the volatility of USDTRY on the volatility of CDS spread can be observed in the short run over a very short period.

In conclusion, these insights and policy implications are valuable for investors, financial risk managers, and policymakers as they provide essential guidance for portfolio composition, risk management, and informed decision-making in the Turkish market. In particularly, investors, portfolio managers and financial risk managers: 1) can hedge stock market positions against rising CDS Spreads, 2) can use USDTRY and 2yBY as a predictor of the 5-year CDS spread, and 3) can use the volatility of 2Yby as a predictor of the volatility of the CDS spread.

Given our findings, policymakers can address sovereign credit risk through fiscal policy. Indeed, rising bond yields, which lead to higher CDS spreads, suggest increased fiscal burdens on the Turkish government. Policymakers should implement prudent fiscal policies to reduce borrowing costs and manage sovereign risk to keep CDS spreads in check. To reduce the volatility of the Turkish CDS spread they should stabilize the USDTRY currency. They can stabilize the Turkish Lira through monetary and fiscal interventions to reduce sovereign credit risk perceptions.

Our findings provide a solid ground for further research and monetary policy deliberations, including time-series modeling with the different macroeconomic and financial variables or dynamic panel modeling with panel-GARCH properties in a larger country or company dataset.

Declarations

Use of AI tools

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Data availability statement

No Data associated with the manuscript.

Ethical approval (optional)

The authors state that this research complies with ethical standards. This research does not involve either human participants or animals.

Consent for publication

Not applicable

Conflicts of interest

The authors declare that they have no conflict of interest.

Funding

No funding was received for this research.

Author's contributions

S.T. Conceptualization, Methodology, Data Curation, Writing-Original Draft Preparation, Formal Analysis, Validation, Software. M.G. Writing - Original Draft Preparation – Review & Editing, Validation.

Acknowledgements

Not applicable

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Mathematical Modelling and Numerical Simulation with Applications (MMNSA)
(https://dergipark.org.tr/en/pub/mmnsa)

How to cite this article: Tüysüz, Ş. and Gül, M. (2024). Investigating Türkiye's financial nexus: A wavelet coherence analysis of sovereign CDS spreads, bond yields, stock index, and FX rates. *Mathematical Modelling and Numerical Simulation with Applications*, 4(4), 395-415. https://doi.org/10.53391/mmnsa.1455355