CAUSALITY BETWEEN STOCK MARKET AND MACROECONOMIC VARIABLES IN TURKEY: NEW EVIDENCE FROM WAVELET COHERENCE ANALYSIS[1]

Remzi GÖK[**]

ABSTRACT

We examine the dependence and causal linkages among selected macroeconomic variables, namely BIST100, bond yields, CDS, currency basket, and gold prices, in Turkey. Using daily data covering the period 2011-01-14 to 2019-04-30, we find the following empirical results. First, all variables are found to be integrated into the first order, namely stationary in first log-difference. Second, our paper detects evidence of significant interdependence in thirteen out of twenty pairs of variables. Third, the findings of the VECM test reveal unidirectional and bidirectional causalities in the short- and long-run. Fourth, the results of wavelet coherence analysis highlight a negative relationship for the pairs of BIST100-currency basket and BIST100-gold prices while positive linkages are observed for the pairs of bond rates-currency basket, bond rates-gold prices, and CDS-gold prices. In addition, the BIST100 index unidirectionally leads currency basket between 16- and 128-day holding periods between 2013-2017 years. Lastly, there exist unidirectional causal linkages among changes in prices for all the pairs of variables, except for BIST100-CDS with noncausality and gold-currency basket with two-way causality. Our findings yield significant implications for portfolio and risk management and financial stability.

Keywords: Wavelets, Stock, Gold, CDS, Causality.

[1] Bu çalışma 10-12 Haziran 2019 tarihlerinde Siirt Üniversitesi'nde "ISPEC'19 Uluslararası Sosyal ve Beşeri Bilimler Kongresi"nde sunulan bildiriden türetilmiştir.

[**] Dr. Arş. Gör., Dicle Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, remzi.gok@dicle.edu.tr, https://orcid.org/0000-0002-9216-5210

İki değerli hakeme katkılarından dolayı teşekkür ederiz.

***Makalenin gönderilme tarihi: 28** Aralık 2019* ***Kabul tarihi: 3** Temmuz 2020*

TÜRKİYE'DE BORSA VE MAKROEKONOMİK DEĞİŞKENLER ARASINDAKİ NEDENSELLİK İLİŞKİSİ: DALGACIK BAĞDAŞIKLIĞI ANALİZİ İLE YENİDEN İNCELEME

ÖZ

Bu çalışmada makroekonomik değişkenlere ait (Bist100, 2 yıllık devlet tahvil faizi, 5 yıllık CDS, döviz sepeti, gram altın) eşbütünleşme ve nedensellik ilişkisi araştırılmıştır. 2011-01-14 ve 2019-04-30 arası günlük kapanış fiyatları kullanılarak önemli ampirik bulgular elde edilmiştir. Öncelikle, tüm değişkenler birinci farkta durağandır. İkincisi, oluşturulan yirmi modelin on üçünde eşbütünleşme ilişkisi tespit edilmiştir. Üçüncüsü, VECM modeline göre kısa ve uzun dönemli tek ve çift yönlü nedensellik bulgularına rastlanmıştır. Dördüncüsü, dalgacık bağdaşıklığı test sonuçlarına göre Bist100-döviz sepeti ve Bist100-altın fiyatları zıt yönde; tahvil faizleri-döviz sepeti, tahvil faizleri-altın fiyatları ve CDS-altın fiyatları aynı yönde hareket etmektedir. Ayrıca, 16-128 günlük periyotta ve 2013-2017 yılları arasında döviz sepeti, Bist100 endeksini tek yönlü olarak takip etmektedir. Durağan değişkenlerin ele alındığı testte, Bist100 ile CDS arasındaki anlamsız ve altın-döviz sepeti arasındaki iki yönlü hariç olmak üzere, diğer değişkenler arasında tek yönlü varyansta nedensellik ilişkisi bulunmuştur. Bu sonuçlar portföy ve risk yönetimi ve finansal istikrarın sağlanmasına yönelik alınacak kararlar için büyük öneme sahiptir.

Anahtar Kavramlar: Dalgacıklar, Hisse, Altın, CDS, Nedensellik.

INTRODUCTION

The effects of macroeconomic variables on stock prices have been widely studied in economic or finance literature for many years. By using different techniques, studies in this theory show that macroeconomic variables directly or indirectly impact stock prices. Since the standard stock valuation model posits that a value of any financial asset, stock or bond, prices are broadly related to its future cash flows, knowing which factor has a great impact on its value, namely on the stock markets, could provide valuable information for portfolio management and policy-making decisions. Among these factors, we select interest and exchange rates, CDS, and gold prices as explanatory variables for movements in stock prices in Turkey. In addition, the interrelationship among our non-stock variables might also be of high importance for market participants in constructing investment and monetary policies. All these interrelationships taken together, we report test results of ten pairs of models in the following sections.

Among these interrelationships, the stock-bond linkage has been one of the most traditional topics in theory. The earliest papers based on this relationship show that rising interest rates are found to influence positively the discount rates in

the asset valuation models, thereby adversely affect stock and bond prices, leading to an inverse bond-stock relationship (see Flannery and James 1984 for details). For the pair stock-exchange rate variables, on the other hand, the literature gives mixed results about the direction of the relationship and offers two main classical theories in understanding the relationship between these markets. The first approach proposed by Dornbusch and Fisher (1980) is the traditional or flow-oriented theory and it posits positively correlation and unidirectional causality from the movements in exchange rates to the stock prices. The second theory proposed by Frankel (1984), on the other hand, is the stock-oriented theory (portfolio balance approach) and it theorizes a negative correlation and unilateral stock returns Granger-causing exchange rate movement. As noted by Andrieș, Ihnatov, and Tiwari (2014), the external balance of the country or the demand and supply of financial assets determines the level of exchange rates under the flow-oriented and the portfolio balance theory, respectively.

In retrospect of the literature, many papers provide evidence of a negative relationship for the pairs of stock-gold and stock-CDS variables. In a pioneering empirical study, Smith (2001) finds a statistically insignificant negative correlation and a long-run relationship between the changes in stock and gold prices in the US. However, the paper reveals that the direction of causation is unidirectional from the stock returns to the London morning fixing and closing gold returns; it is bidirectional for the price set in the afternoon fixing gold prices. In a notable paper, Baur and Lucey (2010) noticeably describe and make a clear distinction of the critical roles of gold prices against stock markets. If gold prices are constantly uncorrelated or negatively correlated with stock prices, then gold prices could be defined as a hedge during tranquil periods or as a safe haven during the turbulent crisis period. Conversely, gold prices could be seen as a diversifier if gold prices correlate positively but imperfectly with stock prices on average. Their findings confirm the function of safe haven in the short-run, namely around three weeks, for the US, UK, and German investors, however, the function is invalid for bond markets during the sample period 1995-11-30 and 2005-11-30. Arouri, Lahiani, and Nguyen (2015), Chkili (2016), and Sakti, Masih, Saiti, and Tareq (2018) reveal similar findings for China, BRIC countries, and Indonesia.

In terms of stock and CDS dynamics, the literature gives a negative relationship between these two markets. In a pioneering work, Merton (1974) proposes the first and most well-known structural credit risk model and report that changes in CDS spread had adverse impacts on stock prices. According to this model, firm defaults when its value, following a stochastic process, falls below a certain threshold. The deterioration in the financial conditions, in other words, raises the probability of default on the underlying debt obligations, with subsequent unfavorable movements in stock and bond prices and favorable changes in the CDS spreads. Among many others, Norden and Weber (2009) find that the CDS spread changes correlate negatively with stock prices as well as bond prices and report a unidirectional causality running from stock markets to the CDS spreads for the EU

and non-EU companies. Delis and Mylonidis (2011) remind that the bond-CDS relationship literature has three main theories: the maturity transformation, herding behavior, and leverage cycles, all of which influence the relationship through the market inefficiencies in the short-term. They also report one-way and two-way causalities during turbulent and crisis periods, respectively. On the other hand, the findings of Malhotra and Corelli (2018) reveal significantly positive and bidirectional causal linkages between the underlying variables for some industrials.

For the CDS-exchange rates relationship, there exist two models in economic theory: the structural approach (see Merton, 1974) and the reduced-form approach (see inter alia Jarrow and Yu, 2001 and Longstaff, Mithal, and Neis, 2003). Zhang, Yau, and Fung (2010), for example, argue that an increase in financial risk leads to a decrease in the value of the local currency against foreign currency, with a subsequent appreciation in CDS spreads. They also assert that there has been a growing recognition regarding the role of the CDS market on macroeconomic variables since the recent GFC crisis among researchers, academicians, and regulators. Their findings, however, conclude that the CDS index spreads correlate negatively with and unidirectionally lead exchange rates in terms of the USD over the period January 2004 to February 2008 and 2007 to 2008. Compared to other variables, the literature for the gold-CDS relationship, in particular, has been relatively scarce. Of this literature, Malhotra and Corelli (2018) provide evidence of a significant negative association between gold returns and CDS spreads and they conclude that three European sectors could hedge their CDS spread risk with investing in the gold market. Akkaya (2017), on the other hand, find that gold prices lead CDS spread in price discovery in Turkey over the sample period extending from January 2008 to March 2016.

There exist several theoretical approaches such as uncovered interest rate parity (Dornbusch, 1976) for the interest rates-exchange rates relationship in the literature. As mentioned above, rising stock prices had led to an increase in wealth and money demand, with the subsequent increase in interest rates and a decrease in exchange rates, pointing to a negative relationship for these two last variables. The uncovered interest rate parity proposed by Dornbusch (1976) also documents an adverse relationship driving by monetary shocks, where the author assumes that both foreign interest rates and forward exchange rates are constant. In other words, this parity states that the level of exchange rates is determined by the interest rate differential of a local and foreign country. A noteworthy result supporting this and the stock-oriented theories is obtained by Hacker, Karlsson, and Månsson (2014). In their paper, the authors reveal evidence of significantly negative linkage at the highest frequencies. At the highest wavelet scales, in addition, the exchange rates are found to be caused by the interest rate differential. In terms of interest rates-gold prices, the literature gives a negative correlation between these series. Baur and Lucey (2010), for example, show that gold prices have served as a hedge in German bond markets, namely gold is negatively correlated with interest rates on average, but not for the US and UK markets. This same result is drawn by

Toraman, Başarır, and Bayramoğlu (2011) for Turkey and Ciner, Gurdgiev, and Lucey (2013) for the US and UK. For the gold price-exchange rate relationship, however, the literature includes many papers that investigate the relationship in terms of a hedge or safe haven. Le and Change (2016) assert that there should be a negative linkage since gold is priced in the dollar. Further, the provide evidence of significantly negative linkage for these variables, namely gold prices correlate positively with stock, however, negatively with interest and exchange rate. Among the commodities, gold prices correlate the highest in absolute value with the exchange rate and the lowest with stock prices in Japan. On the contrary, Ingalhalli et al. (2016) find a moderate positive correlation between gold and exchange rates and unidirectional causality from exchange rates to gold prices. They suggest not investing in gold during the crisis period in India.

We examine the dependence and causal linkages among a few selected financial variables, namely Bist100, bond yields, CDS, currency basket, and gold prices, in Turkey. Using daily data covering the period 2011-01-14 to 2019-04-30, we find the following empirical results. First, all variables are integrated into the first order, namely, they become stationary in first log-difference. Second, our paper detects evidence of significant comovement in thirteen out of twenty pairs of variables, including bond yields to CDS rates and currency rates to the Bist100 index in the long-run. Third, the findings of the VECM test reveal, for example, two-way causal relations for the pairs of CDS-Bist100, CDS-currency basket, and Bist100-bond yields variables in the short-run. Fourth, the results of wavelet coherence analysis highlight a negative relationship for the pairs of BIST100-currency basket and BIST100-gold prices while positive linkages are observed for the pairs of bond yields-currency basket, bond yields-gold prices, and CDS-gold prices. In addition, it is observed that some variables, namely the pairs of bond yields-currency basket and gold-bond yields, are found to be in phase in the last two years, namely in 2018-2019, in the medium term corresponding to 32- and 256-day holding periods. Lastly, with two exceptions, the paper reports unilateral causal linkages in variance among all the pairs of first-differenced variables. Our findings, in general, yield significant implications for investors in building portfolio and risk management decisions and for policy-makers in constructing monetary policies.

The rest of the paper is structured as follows. We briefly provide relevant literature in section 2. The following section 3 lays down the empirical methodology and presents the relevant literature for the approaches we used. In section 4, we present and discuss our empirical findings. Lastly, section 5 offers concluding remarks for investors and policy-makers.

I. LITERATURE REVIEW

In retrospect of the literature, there is a bulk of empirical studies that investigate the relationship between stock markets and macroeconomic variables in terms of correlation, cointegration, and causality relationships. The most recent and

notable, among many others, papers in this literature include Aloui, Jammazi, and Hamida (2018), Andrieş et al. (2014), Baur and Lucey (2010), Ciner et al. (2013), Gün, Kutlu, and Karamustafa (2016), Kim (2003), Le and Change (2016), and Živkov, Njegić, and Pećanac (2019) for the stock-bond market relationship; Akkaya (2017), Başarır and Keten (2016), Forte and Pena (2009), Malhotra and Corelli (2018), Norden and Weber (2009), Şahin and Özkan (2018), and Shahzad, Aloui, and Jammazi (2020) for stock-CDS linkage; Bhunia (2013), Dahir, Mahat, Ab Razak, and Bany-Ariffin (2018), Granger, Huangb, and Yang (2000), Ingalhalli et al. (2016), and Tiwari, Bhanja, Dar, and Islam (2015) for stock-exchange rate association; Arouri et al. (2015), Balı and Cinel (2011), Chkili (2016), Jain and Biswal (2016), Smith (2001), and Toraman et al. (2011) for stock-gold relationship.

The pioneering work of Granger et al. (2000) provides evidence of significant causalities between the stock and exchange rate markets for the 9 Asian countries over a sample period extending from 1986-01-03 to 1998-06-16 with a total of 3247 observations and yields several important results. First, it confirms the validity of the traditional approach (flow-oriented theory) for South Korea, namely the exchange rates unidirectionally cause the stock prices during the Asian flu period. The reverse causal linkage, on the other hand, is detected for the Philippines, confirming the portfolio rebalancing theory (stock-oriented theory), in other words, the correlation is negative and the current stock prices could be used to predict the future movements in the exchange rates. Secondly, it purports two-way linear causalities for Singapore, Hong Kong, Thailand, Malaysia, and Taiwan, but it fails to detect significant causal linkage for Japan and Indonesia. In a relevant paper, Kim (2003) uses monthly observations of stock prices and selected macroeconomic variables over the sample period from January 1974 to December 1998, and reports that the stock prices are adversely affected by the interest and exchange rates, whereas it co-moves with the industrial production in the US. The findings show that the stock prices considerably affect the movements in the inflation and exchange rates while the reverse effect is true for the interest rates and industrial production in the long-run. Further, the innovations in the interest rates are found to significantly drive the movements in the exchange rates.

Baur and Lucey (2010) examine the constant and rolling associations between gold with bond and stock markets in the US, UK, and Germany to find out that whether gold is a hedge or safe haven during the extreme market conditions through GARCH models. Their study demonstrates that, on average, gold is a safe haven for only stocks. Further, gold is generally not a safe haven for bonds in any market conditions, namely, its hedging effectiveness holds only for the short-run. The safe-haven role of gold against exchange rate fluctuations, on the other hand, is evidenced by Ciner et al. (2013) during the stock market turmoil periods, highlighting the role of gold as a monetary asset in both the US and UK. The noteworthy finding they reveal, however, is that the currency markets could be regarded as a safe haven against the fluctuations in stock, bond, and gold markets

during the extreme market conditions. Le and Chang (2016), on the other hand, suggest that the daily gold prices and bond rates adversely affect equity prices in the long run. The fluctuations in stock and gold prices seem to be inversely related to the short-term interest rates in the long-run in Japan between the sample period 1997 and 2016. They strongly recommend using the changes in gold and oil markets to predict the movement in equity and bond markets for policy and investment decisions. In a recent paper, Živkov et al. (2019) reveal, as expected in theory, a significantly negative correlation at scales from 2 days to 128 days between the bond rates and stock returns for Turkey, Russia, Hungary, and Romania. The correlation is negative up to the fifth scale and switches sign, however, from negative to positive beyond the sixth scale in Czech and Poland. In other words, these markets could be used as a hedging tool at lower scales and for diversification at higher scales. The findings of the phase difference of the wavelet cross-spectrum also show that both variables are out of phase and move in the reverse direction at medium and higher time scales in all countries, pointing to the validity of dividend discount model and the portfolio rebalancing activities, with exceptions for Czech and Polish markets with positive relations and tactical asset allocation activities. Further, they show that the bond market leads the stock market in Turkey between 2016 and 2018 over 16-64 days cycles due to the existence of relatively high inflation rates. A partially corroborating result is obtained by Aloui et al. (2018), who revealed that stock returns and Islamic bond yields move in the same and opposite directions in the short and longer time-scales, respectively.

Through the adjustment process and VAR models, Norden and Weber (2009) study the dynamic linkages between daily, weekly, and monthly observations of CDS, bond, and stock market prices during the period 2000-2002 for a set of 58 firms operating in different sectors including financial, automotive, and telecommunication. Their results report significantly negative correlation between the CDS spread changes with the changes in stock and bond rates. The CDS markets are found to have a stronger sensitivity to the changes in stock markets than bond markets where the credit quality of the underlying firms and the size of bond issues considerably influence the strength of this sensitivity. Furthermore, they report a one-way causality from the stock returns to the CDS and bond rates and from the CDS movements to the bond rates. Forte and Pena (2009), show that stock prices of 65 individual firms lead CDS spreads in price discovery (24/65) more frequently than the opposite (5/65). Şahin and Özkan (2018), on the other hand, present evidence of significant cointegration relation among stock, exchange rates, and CDS spread. The result of the study detects bidirectional causality, confirming a form of feedback mechanism between the stock returns and the CDS changes in Turkey. Shahzad et al. (2020), using continuous wavelet coherence method, report significantly negative relationships that intensifying over different time scales between the U.S. based sectoral indices CDS spreads.

The study of Arouri et al. (2015) documents new evidence for return as well as volatility spillover effects from the gold market to the stock market in

China and they suggest adding gold to a portfolio consisting of Chinese stocks to reduce portfolio's total risk and thus improve its risk-adjusted returns. In particular, they argue that gold was a safe haven for the Chinese stock market during the recent GFC crisis period. In line with these results, Chkili (2016) purports that the gold-stock market correlation switches sign from negative to positive and vice versa for the BRIC countries during the tested period between January 2000 and July 2014. Jain and Biswal (2016), on the other hand, investigate the relationship between global gold, crude oil, and stock prices and exchange rates in India. Using DCC-GARCH models and nonlinear causality tests, they highlight a two-way asymmetric causality between the negative components gold prices and SENSEX index and the role of gold as a hedging investment asset against the others during the recession and crisis periods. Dahir et al. (2018) report significantly positive correlation and strong evidence for exchange rates Granger-causing stocks, confirming the validity of the traditional approach for Brazil and Russia. Conversely, they discover evidence in favor of the portfolio rebalancing theory for India over different periods.

For the pairs of CDS-interest rates and CDS-exchange rates, the literature includes an abundant amount of papers on these relationships. Empirical studies reveal causal relation from the changes in CDS to the bond rates (Aktug, Vasconcellos, and Bae, 2014;), report causation from the movements in bond rates to the CDS spreads (Aktug et al., 2014; Delis and Mylonidis, 2014), detect causal linkages in both directions (García, Valle, and Marín, 2014; Delis and Mylonidis, 2014), and find causality in neither direction (Aktug et al., 2014; Aksoylu and Görmüş, 2018). Of the studies, Aksoylu and Görmüş (2018) fail to identify evidence of unidirectional causality from the US interest rates to the CDS changes in nine developing countries, such as Turkey, Brazil, and Indonesia. Delis and Mylonidis (2014), on the other hand, report that the direction of causation is bidirectional for Greece, Portugal, and Spain and is unidirectional from the interest rates to the CDS spreads for Italy. García et al. (2014) document significant long-run equilibrium relation for the markets in Spain, France, Italy, Argentina, Brazil, and China. They also identify evidence of the bidirectional Granger-causal linkages for all countries at different lag levels. In a related study, Gün et al. (2016) examine the effect of social events on the CDS rates and the relationship among some selected macroeconomic variables in Turkey. Their paper suggests that the social events unidirectionally Granger-cause the CDS rates and the stock market volatility, whereas it provides strong evidence of bidirectional causal linkages between the Gezi Park events and bond rates. Further, it detects one-way causalities between the CDS changes and with each of the movements in exchange rates, stock market volatility, and interest rates. In addition, the findings reveal that the CDS changes are a Granger cause of the movements in bond, stock, and foreign exchange markets with no reverse causality. The findings of the paper, however, support the presence of bidirectional causal linkage for the pairs of stock-bond markets and purport unidirectional causality from the fluctuations in bond rates to

the exchange rate changes. Using daily observations of four currencies including JPY, EUR, GBP, and AUD in terms of both EUR and USD, Zhang et al. (2010) reveal strong evidence for CDS Granger-causing exchange change rates (in terms of USD) for the whole period and during the recent GFC and conclude that the movements in CDS may proclaim significant carry-trade information for USD market investors. Başarır and Keten (2016), on the other hand, highlight a long-run relationship among stock prices, exchange, and CDS in Turkey. The findings show no causation in the long-run, however, reveal short-run bidirectional and unilateral causality for the CDS-stock prices and the CDS-exchange rates at different significance levels, respectively. There is a vast literature (see among many others, Andrieş et al., 2014; Baur and Lucey, 2010; Elmas and Polat, 2014; Le and Change, 2016, Özpınar, Ö., Özman, H. and Doru, 2018; and Yıldız, 2014) that investigates the relationship among interest rates, exchange rates, and gold prices in both developed and emerging countries. Of this literature, Özpınar et al. (2018), employing cointegration and causality tests on stock, exchange rate, and CDS spreads, reveal evidence of significant comovement and one-way and two-way causal linkages in Turkey. In other words, there exist bidirectional causality between changes in the exchange rate and interest rates and unilateral causality from the changes in exchange rates to the CDS movements. The test, however, fails to discover any causation relationship between the interest rate fluctuations and the CDS movements. Using the same methodology, Yıldız (2014) reports an insignificant long-run relationship among the stock, gold, interest rates, and exchange rates in Turkey. The findings, on the other hand, show a two-way causality for the pairs of stock and exchange rates, and unidirectional causalities for the pairs of gold and exchange and for the pairs of interest rates and stock prices over the sample period between March 2001 and June 2016. Further, they suggest using all variables for short-run portfolio diversification. By applying the cross-wavelet coherency and the phase difference approaches, Andrieş et al. (2014) provide evidence of comovement between interest rates and exchange rates for the sample period July 1997 and December 2010 in India. In addition, changes in the stock market are led by both the movements in interest and exchange rates. In a related paper, Elmas and Polat (2014) detect that gold prices correlate positively with the DJIA index (significantly) and interest rates (insignificantly). Balı and Cinel (2011), on the other hand, find that stock prices correlate negatively with exchange and interest rates whereas it co-moves with gold prices in Turkey.

Among many others, notable studies under the exchange rates-gold price relationship literature contain Altarturi, Alshammari, Saiti, and Erol (2018), Bhunia (2013), Elmas and Polat (2014), Ingalhalli et al. (2016), Tokat (2013), Toraman et al. (2011), Yıldız (2014), etc. Of this strand of literature, the results of the conditional correlation test by Toraman et al. (2011) purport that the highest, and the only significantly negative, correlation is between the movements in gold prices and the exchange rates among the studied assets in Turkey. Namely, the gold returns move negatively with the DJIA and interest rates however, their estimated

correlation coefficients are statistically insignificant. Further, the DJIA returns correlate negatively but insignificantly with the exchange rates and the interest rates. Altarturi et al. (2018) ascertain that movements in the USD exchange rates affect the gold prices in the reverse direction in the short- and medium-term. Using an asymmetric multivariate MGARCH model, Tokat (2013) finds heteroskedasticity of volatility in stock, gold, and exchange rates and argues that the stock index could be used as a safe haven against other assets in Turkey. Evidence published in the paper of Bhunia (2013), on the other hand, reveals unidirectional causalities running from the exchange rates to the gold prices and from the gold prices towards the stock prices in India. However, the findings also show that the stock market co-move with, but doesn't lead by the exchange rates during the sample period from 1991-01-02 to 2012-12-31. Ingalhalli et al. (2016) study the relationship among exchange rates and stock and gold prices in India using daily observations from January 2005 to July 2015. Albeit to varying magnitudes and significance levels, the variables are found to correlate positively with each other. Their empirical results also show that the gold returns Granger-cause the exchange rate returns and they are caused by the stock returns. Similarly, the stock returns unidirectionally Granger-cause the fluctuations in exchange markets.

The literature for the gold-CDS relationship, in particular, has been relatively scarce. Of the papers, Malhotra and Corelli (2018) investigate stock and macroeconomic variables, including CDS, interest rates, and gold prices, for a sample of 9 different sectors in Europe and the USA over the period 2007/12/14–2017/09/01. Their findings reveal that the CDS spreads are found to co-move and show bidirectional causal linkages with the changes in interest rates during the GFC crisis period. The results provide evidence of a significantly negative association between gold returns and CDS spreads and they conclude that three European sectors could hedge their CDS spread risk with investing in the gold market. Further, their paper detects strong evidence of one-way causality running from the gold returns to the CDS spreads for the banking and transportation sectors whereas the reverse is true for the financial industry during the recent financial crisis period in the US. In a recent paper, Akkaya (2017) investigates the impacts of CDS spreads on the selected macroeconomic variables in Turkey over a sample period extending from January 2008 to March 2016, for a total of 99 monthly observations. Their study reveals potent unidirectional causalities, namely the changes in CDS lead the reel effective exchange rate in price discovery and caused by the gold and stock returns.

This study stems from the necessity to offer a deeper understanding of stock markets - macroeconomic factors as the current literature has produced ambiguous and mixed results using only time-based methods. By employing wavelets as well as standard approaches, the paper tries to uncover the true dynamics of relationships among financial markets that may be hidden over different time horizons since the current literature is scarce for Turkey's case.

II. METHODOLOGY

In this study we employ two widely-used preliminary tests with structural breaks for causality relations, namely the Lee and Strazicich (2003) approach is used for the unit root testing while Hatemi-J (2008) method is preferred for cointegration relationship for the pairs of the nonstationary variables. If our variables are found to be integrated into the first order and cointegrated, we proceed to examine the causality association using the VECM form. For the pairs of the non-cointegrated variables, wavelet coherence is used to detect possible lead-lag and correlation linkages in the time-frequency plane. Finally, we investigate the causal relationship in variance employing the test of Hafner and Herwartz (2006) method for the pairs of stationary variables. In the following, the technical details of some tests, namely Lee and Strazicich (2003) unit root and Hatemi-J (2008) cointegration test, are left to the reader for the reason of brevity.

A. HAFNER AND HERWARTZ (2006) CAUSALITY-IN-VARIANCE TEST

In their empirical study, Hafner and Herwartz (2006) begin by supposing stationarity of $\{\varepsilon_t\}$ and $E[\epsilon_t|\aleph_{t-1}] = 0$ with the condition of $\{\varepsilon_t \in \mathbb{R}^N, t \in \mathbb{N}\}$. In order to test of causality in variance, they suggest using the subsequent null hypothesis as given

$$H_0: VAR(\varepsilon_{it}|\aleph_{t-1}) = VAR\left(\varepsilon_{it}|\aleph_{t-1}^{(j)}\right), \tag{1}$$

where $= 1, \dots, N$, $j \neq i$, and $\aleph_t^{(j)} = \aleph_t \backslash \sigma\left(\varepsilon_{j\tau}, \tau \leq t\right)$. In addition, they offer the following model for testing the null hypothesis

$$\varepsilon_{it} = \mathfrak{H}_{it}\sqrt{\sigma_{it}^2 \mathcal{s}_t}, \quad \mathcal{s}_t = 1 + \varkappa_{jt}'\omega\,, \quad \varkappa_{jt} = \left(\varepsilon_{jt-1}^2, \sigma_{jt-1}^2\right)' \tag{2}$$

where σ_{it}^2 is equal to $\varphi_i + \mathcal{a}_i\varepsilon_{i,t-1}^2 + \mathcal{b}_i\sigma_{i,t-1}^2$ and $\mathcal{H}_{it}$ denotes the standardized residuals of the GARCH process. Likewise, the parameter ε_{it}, i.e. the score of the Gaussian log-likelihood function, is determined as $x_{it}\left(\mathfrak{H}_{it-1}^2\right) * 0.5$ with the conditions of $x_{it} = \sigma_{it}^{-2}\left(\partial\sigma_{it}^2/\partial\Phi_i\right)$ and $\Phi_i = (\kappa_i, \mathcal{a}_i, \mathcal{b}_i)'$. A necessary condition for the model given in equation (2) is $\omega = 0$, thereby, one can formulate, respectively, the null and alternative hypotheses as $H_0: \omega = 0$ and $H_0: \omega \neq 0$. Finally, they recommend the following the LM test statistic constructed from univariate GARCH processes as given

$$\lambda_{LM} = 0.25T\left(\sum_{t=1}^{T}\left(\mathfrak{H}_{it-1}^2\right)\varkappa_{jt}'\right)\frac{1}{\Omega(\Phi_i)}\left(\sum_{t=1}^{T}\left(\mathfrak{H}_{it-1}^2\right)\varkappa_{jt}\right) \xrightarrow{d} \chi^2(2) \tag{3}$$

where the number of misspecification indicators in $\varkappa_{jt}$ establishes the asymptotic distribution of the LM test statistic, thus, it will include two degrees of freedom for asymptotic chi-square distribution.

B. WAVELET COHERENCE AND PHASE DIFFERENCE

Given that the use of wavelet analysis is a well-established approach in the literature, we will briefly, namely without delving into its details, discuss the essential methods, including wavelet coherence and wavelet phase difference, for our purposes (see Torrence and Webster, 1999 for details).

Given two time series X and Y, the cross-wavelet spectrum (wavelet periodogram or scalogram) can be written by the following expression (Torrence and Webster, 1999)

$$W_n^{XY}(d) = W_n^X(d)W_n^Y *(d) \tag{4}$$

where $W_n^X(d)$ and $W_n^Y(d)$ denote the wavelet transforms of X and Y. Besides, n, d, and $*$ represent time index, scale, and complex conjugate, respectively. Since the cross-wavelet spectrum is complex, it can be also defined as $|W_n^{XY}(d)|$.

Following the authors, one could write the squared wavelet coherence as

$$R_n^2(d) = \frac{\left|S\left(\frac{1}{d}W_n^{XY}(d)\right)\right|^2}{S\left(\frac{1}{d}|W_n^X(d)|^2\right).S\left(\frac{1}{d}|W_n^Y(d)|^2\right)} \tag{5}$$

where S indicates smoothing in both scale and time. The authors defined this definition as the absolute value squared of the smoothed cross-wavelet spectrum which is normalized by the smoothed individual wavelet power spectra. Note that, d^{-1} factor is used to convert an energy density and the value of wavelet coherence, $R_n^2(d)$, ranges from 0 to 1, namely it is $0 \leq R_n^2(d) \leq 1$. Grinsted, Moore, and Jevrejeva (2004) state that wavelet coherence could be seen as a localized correlation coefficient in the frequency-time plane where its statistical significance level is estimated using Monte Carlo simulation methods.

Using equation (4) in conjunction with equation (5) gives the following definition for the wavelet-coherence phase difference (Torrence and Webster, 1999)

$$\phi_{x,y}(d) = \frac{1}{\tan}\left(\frac{\mathcal{J}\left(\left(\frac{1}{d}W_n^{XY}(d)\right)\right)}{\Re\left(\left(\frac{1}{d}W_n^{XY}(d)\right)\right)}\right) \tag{6}$$

where $\mathcal{J}$ and $\Re$ parameters, respectively, signify the imaginary and smoothed real components of the smooth power spectrum. Note that, the wavelet coherence phase is used to characterize phase, namely the lead-lag, relationships between two time series and will be detailed in the following section.

The phase difference and correlation relationship between the underlying series are depicted by arrows. In other words, the phase difference between the underlying series can be represented by the orientation of the arrows in the high coherence regions. For example, the arrows pointing rightward (→) denotes a positive correlation and that the two series are in phase while the arrows pointing leftward (←) implies that they are out of phase (anti-phase) and move in the reverse direction. Furthermore, the arrows pointing to the left and up (↖) and to the right and down (↘) indicate that the first variable leads the second while the arrows pointing to the right and up (↗) and to the left and down (↙) suggest that the second leads the first variable.

III. EMPIRICAL RESULTS AND DISCUSSION

To conduct our analysis, we use daily closing prices of Bist100 index, 2-year government bond rates, 5-year CDS, currency basket (0.50*USDTRY + 0.50*EURTRY), and gold prices per gram in TRY from January 14th, 2011 to April 30th, 2019, with a length of 2048 trading days after excluding national holidays and non-working days in Turkey. Our dataset is obtained from the EVDS database of the CBRT and two websites (https://www.investing.com & https://www.gold.org/goldhub/data/gold-prices). Summary statistics for the growth rate of variables, defined as logarithmic first difference and multiplied by 100, are provided in Table 1.

Table 1. Descriptive Statistics

Variables	DL_BOND	DL_CDS	DL_BIST100	DL_CURRENCY	DL_GOLD
Mean	0.0569	0.0544	0.0166	0.061	0.0624
Median	0	-0.0196	0.0744	0	0.0305
Max	13.5262	23.3509	6.2378	9.4882	8.3589
Min	-8.358	-18.4415	-11.0637	-6.8585	-9.3165
Std Dev	1.3332	2.9793	1.4071	0.8116	1.3111
Skewness	1.1511	0.5653	-0.603	1.5337	0.029
Kurtosis	13.8844	10.5402	6.7645	29.0341	8.0612
JB	10556.73***	4958.3***	1332.78***	58611.39***	2185.11***
T	2047	2047	2047	2047	2047

Note: *, **, or *** signify, respectively, rejection of the null hypothesis at the 10%, 5%, and 1% significance levels.

During our period, all variables provided positive return rates and stock returns have remained below the remaining alternative investment instruments in

terms of average and maximum values. Gold prices per gram and currency basket, however, yield the highest return rates of 6.24% and 6.10% with a standard deviation of 1.311 and 0.812, respectively. CDS (23.35%) and bond rates (13.53%) display by far the highest daily changes among the investment instruments during the currency crisis in August 2018 and after the announcement of the press release on the summary of the monetary policy committee meeting, respectively. As evident from Table 1, except Bist100, the other four variables exhibit positive skewness and all five growth rates display excess kurtosis. All these and JB findings taken together show that our data have an asymmetrical distribution with a longer right, except for Bist100 with longer but left, heavy tails and thus indicate a rejection of normality assumption.

Table 2. Lee and Strazizich (2003) unit root test

Variable	Model A			Model C		
	LM test	BP1	BP2	LM test	BP1	BP2
LN_BOND	-2.453	2013-06-13	2015-01-02	-4.279	2012-08-15	2017-12-01
LN_CDS	-2.192	2013-06-24	2014-12-16	-3.251	2012-09-13	2018-01-11
LN_BIST	-2.716	2013-06-13	2017-01-11	-3.806	2012-12-07	2017-04-07
LN_FX	-2.418	2014-01-28	2018-05-23	-4.412	2012-05-23	2018-04-19
LN_GOLD	-1.724	2013-04-12	2018-05-23	-4.387	2011-12-08	2014-08-06
DL_BOND	-2.55	2011-12-30	2016-05-23	-9.267***	2011-12-27	2013-06-18
DL_CDS	-9.517***	2011-12-16	2012-11-29	-15.177***	2012-09-12	2014-06-05
DL_BIST	-4.379**	2014-09-29	2016-05-17	-14.686***	2013-06-04	2015-11-23
DL_FX	-9.436***	2013-04-08	2016-07-20	-17.271***	2015-10-30	2018-05-24
DL_GOLD	-5.744***	2014-02-10	2016-03-30	-16.567***	2012-01-24	2013-06-28

Note: *, **, or *** indicate rejection of the null hypothesis of unit root at 10%, 5%, or 1% significant levels, respectively. The abbreviation BP1 (BP2) stands for the first (second) breakpoint. Model A is a model with a break in intercept while Model C is a model with a break in intercept & trend.

Results of the preliminary analysis for the raw and the first-differenced data reported in Table 2. Before cointegration and causality testing, we perform the minimum LM unit root test of Lee and Strazicich (2003) with two structural breaks to identify unit roots in all underlying variables. The findings suggest the presence of unit roots in all price series; namely, it indicates that the shocks are permanent since there is not any evidence against the null hypothesis in favor of level (Model A) and trend (Model C) stationarity with double structural breaks. Conversely, the test reveals stationarity in the first log-difference of price series, implying that the persistence of shocks is limited. In other words, the test findings show that 4 out of 5 variables are stationary around a broken trend and all series are shown to be trend-stationary when Model A and Model C are used, respectively. It can be concluded that, therefore, our variables are integrated into the first order, $I(1)$, regardless of the model chosen. Given the outcome of the Lee and Strazicich (2003) unit root test, we proceed to investigate whether or not prices are collinear

in the long run by employing the Hatemi-J (2008) cointegration approach with two unknown breaks and report its results in Table 3.

Table 3 presents the empirical findings of the Hatemi-J (2008) cointegration test with two endogenous breaks among the pairs of nonstationary variables. Obviously, we strongly reject the null hypothesis of no cointegration for the 13 out of the 20 pairs of variables, namely we fail to reject the null for "LN_BOND~LN_GOLD", "LN_CDS~LN_GOLD", "LN_BIST~LN_FX", "LN_BIST~LN_GOLD", "LN_FX~LN_BOND", "LN_GOLD~LN_BOND", and "LN_GOLD~LN_CDS" pairs, indicating that the tactical asset allocation strategy is warranted since these variables move apart over time. "LN_BOND" is, however, found to co-move with the prices of CDS, Bist100, and currency basket.

Table 3. Hatemi-J (2008) cointegration test

	Dependent	ADF	BP1	BP2	Phillips Za	BP1	BP2
LN_BOND	LN_CDS	-5.801*	2015-07-09	2016-03-30	-64.031*	2015-07-10	2016-03-29
	LN_BIST	-5.854*	2013-08-02	2016-01-08	-57.829*	2013-07-15	2015-12-18
	LN_FX	-5.327	2013-08-12	2015-02-05	-63.372*	2013-09-02	2015-01-13
	LN_GOLD	-5.168	2015-05-08	2015-09-08	-44.309	2015-04-07	2015-08-28
LN_CDS	LN_BOND	-5.848*	2012-06-01	2016-02-15	-65.072*	2012-05-31	2016-02-16
	LN_BIST	-5.6	2012-11-08	2015-12-22	-56.495*	2012-11-16	2015-12-18
	LN_FX	-5.854*	2012-08-14	2016-01-04	-79.511**	2013-09-02	2015-11-19
	LN_GOLD	-5.14	2013-05-22	2016-01-04	-51.147	2013-05-20	2015-11-18
LN_BIST	LN_BOND	-5.708*	2013-04-24	2016-06-13	-58.839*	2013-05-24	2016-09-06
	LN_CDS	-5.143	2015-01-20	2016-07-11	-60.142*	2013-05-24	2016-09-06
	LN_FX	-4.603	2015-06-10	2016-05-27	-37.555	2015-05-14	2016-09-06
	LN_GOLD	-4.911	2015-07-02	2016-09-28	-41.401	2015-05-15	2016-09-08
LN_FX	LN_BOND	-5.486	2012-08-28	2015-02-23	-47.47	2012-08-09	2015-02-09
	LN_CDS	-6.216**	2012-09-18	2015-12-28	-83.022**	2012-08-31	2015-11-19
	LN_BIST	-5.702*	2012-09-20	2016-02-10	-57.961*	2012-09-18	2016-02-15
	LN_GOLD	-7.066***	2013-04-26	2014-12-24	-96.213***	2013-04-18	2014-11-25
LN_GOLD	LN_BOND	-3.899	2014-11-24	2014-12-16	-23.615	2013-04-04	2015-01-13
	LN_CDS	-4.149	2012-06-27	2016-04-05	-45.639	2012-07-20	2016-02-15
	LN_BIST	-5.668*	2012-09-28	2016-02-12	-58.54*	2012-09-17	2016-02-22
	LN_FX	-6.557***	2013-05-30	2014-11-26	-89.841**	2013-04-09	2014-11-25

Note: *, **, or *** indicate significant cointegration relationship at the 10%, 5%, or 1% significant levels, respectively. The abbreviation BP1 (BP2) stands for the first (second) breakpoint. The gray shaded areas represent nonsignificance.

Similarly, "LN_CDS" in Turkey moves in tandem with bond rates, Bist100, and currency basket, implying that CDS is collinear with those prices in the long-run. "LN_BIST", on the other hand, form a cointegration relationship with

bond and CDS rates, indicating that the Bist100 index shares a nonstationary component with those variables. The average of USDTRY and EURTRY, currency basket, "LN_FX", has significant cointegration relationships at any conventional significance level with CDS rates, Bist100, and gold prices in the long-run. The test also analyzes whether or not gold prices are collinear with the other four variables, and discover that "LN_GOLDS" co-moves only with the prices of the Bist100 index and currency basket in the long-run. The presence of cointegration relationships founded among our variables has ruled out non-causality among variables. Therefore, the direction of the short- and long-run causal linkages for the pairs of cointegrated variables must be tested by employing the method of Granger causality based on VECM.

Table 4. VECM Granger causality test results

Independent		**Dependent**	**Lag**	**χ^2 Statistics**	**ect_{t-1}**
LN_BOND	⇏	LN_CDS	3	4.51711	-0.01127***
LN_BOND	⇏	LN_BIST	12	24.76608**	-0.00288
LN_BOND	⇏	LN_FX	10	311.1529***	-0.00016
LN_CDS	⇏	LN_BIST	2	23.55562***	-0.00157*
LN_CDS	⇏	LN_FX	2	436.498***	0.0001
LN_BIST	⇏	LN_FX			
LN_FX	⇏	L_GOLD	2	16.83489***	-0.00644**
LN_BIST	⇏	L_GOLD			
Independent		**Dependent**	**Lag**	**χ^2 Statistics**	**ect_{t-1}**
LN_CDS	⇏	LN_BOND	3	16.62729***	0.00096
LN_BIST	⇏	LN_BOND	12	32.60252***	-0.00154**
LN_FX	⇏	LN_BOND			
LN_BIST	⇏	LN_CDS	1	1.12857	-0.0053***
LN_FX	⇏	LN_CDS	5	27.3042***	-0.00782***
LN_FX	⇏	LN_BIST	2	4.60886*	-0.00681***
L_GOLD	⇏	LN_FX	2	3.60914	0.00181
L_GOLD	⇏	LN_BIST	2	2.21459	-0.00612***

Note: *, **, or *** indicate significant causality at 10%, 5%, or 1% significant levels, respectively. Chi-Square statistics denote short-run and error correction term indicates long-run causality.

As reported in Table 4, the VECM test presents evidence of short-run causality with the chi-square statistics, χ^2, and of long-run causality with the error correction term, ect_{t-1}, which also indicates the speed and significance of the long-run error adjustment. The findings show that "LN_BOND" co-moves with and Granger-causes "LN_CDS" in only the long-run, however, it led by "LN_CDS" in only short-run. In addition, there seems to be a bidirectional short-run causality but a one-way long-run causality with "LN_BIST". Similarly, "LN_ BOND" has significant short-term causes, 311.15***, on currency basket during our period. On

the other hand, the results of the VECM test also show that "LN_BIST" and "LN_FX" variables have short-run and long-run reciprocal and short- and long-run one-way causal linkages with "LN_CDS" in Turkey. Also, there is strong evidence of a unilateral short- and two long-run causalities running from "LN_FX" and "LN_GOLD" to "LN_BIST", respectively, indicating that the currency basket and gold prices could be used to predict the future movements of the stock markets in the short- and long-run but not vice versa. Finally, the currency basket rates are found to have a unilaterally significant lagged impact on the gold prices in the short- and long-run, namely, the changes in currency basket might be used as a reasonable indicator of current development in gold prices, and not the other way around. The significantly negative adjusted coefficient, -0.00644**, on the other hand, suggests that the potential disequilibrium of the long-run relationship between "LN_FX" and "LN_GOLD" will be restored in the following 155.3 days if they deviate from the long-run equilibrium.

The wavelet coherence between the pairs of nonstationary and non-cointegrated variables is depicted through contour plots in the following figures. Each figure comprises of three dimensions, namely frequency which is converted into time units (days) and time components are represented on the vertical (*Y*-) and horizontal (*X*-) axes, respectively, while wavelet coherence power spectrum is depicted by a color code in the right-hand ranging from dark-blue (low) to dark red (high) values. It should be noted that the thick and curved black contour shows the 5% level of significance against red noise and the cone of influence indicating the region affected by edge effects, therefore, requiring more caution in interpreting results. It is necessary to note that, for wavelet coherence computations with Morlet wavelet, we execute a publicly available MATLAB code, *wtc(x,y,[,settings])*, provided by Grinsted et al. (2004).

Figure 1 depicts the squared wavelet coherence, WTC, for the pairs of "LN_BOND~LN_BASKET" and "LN_BOND~LN_BASKET" variables. A perusal of figure reveals that, as shown in the upper panel, the bond prices and currency basket rates, as expected and in common in existing theory, move together over frequency bands and across time scales, namely, they are in phase. For example, as the arrow → visibly indicates, that there is a significantly positive relationship between "LN_BOND" and "LN_BASKET" in the 32~512 days frequency band between 2013 and 2019, implying that both variables have a cyclical effect on each other. This result reinforces the findings of Hacker et al. (2014) who detect a positive relationship at the highest wavelet scales, driving by increasing inflationist pressure in Turkey. It also reveals that during late 2017 and late 2018, arrows are right down (↘), hence, "LN_BOND" is leading "LN_BASKET" over 16–64 days cycles. During mid-2018 and late 2019, in the time scale of 96–180 days, we find that the arrows pointing to the right and up, ↗, show that the currency basket rates are leading. In line with our results, Andrieş et al. (2014) reveal time and frequency varying lead/lag relationship among stock prices, exchange, and interest rates by employing the same approach for India case.

Conversely, the stock prices and currency basket rates, as depicted in the bottom panel, are negatively correlated and they are out of phase between 2013 and 2015 over 128-256 days cycles, suggesting that they have an anti-cyclical impact on each other. In addition, the significant lead-lag relationship is more intensified in the intermediate frequency bands, mainly between 8 and 180-day holding periods. For instance, the arrows are pointed to the left and up, ↖, suggesting that the currency basket rates lead the stock prices between late 2013 and 2015 over 32-64 days cycles and between mid-2015 and mid-2016. The reverse causality, ↙, can also be observed over 32-64 days cycles during early 2014. This agrees with the results from Granger et al. (2000), Kim (2003), and Balı and Cinel (2011), who report negative correlation and significant evidence for stock prices Granger-causing exchange rates through the wealth effect, confirming the validity of the stock-oriented approach in Turkey.

For the pair of "LN_GOLD~LN_BOND", "LN_GOLD~LN_CDS", and "LN_GOLD~LN_BIST100", the squared wavelet coherence is depicted in Figure 2. As shown in the upper panel, for the pair of gold–interest rates and in the significant zone, namely in the red-colored islands, the arrows are pointed rightward, →, indicating that variables are in phase and co-move between 2013 and 2014 over 32-64 and 96-256 day holding periods. The arrows, ↗, located in the time scale of 96–180 and between the mid-2015 and 2016 and in the time scale of 20–80 days and between 2018 and late 2019 indicate that the underlying series are out of phase and the bond rates are leading gold prices. In the time scale of 64–96 days and between early 2013 and end of 2014, however, the gold prices are leading the interest rates in Turkey.

For the pair of Gold–CDS and in the significant are, the arrows are pointing to the left and down, ↘, suggest that they are out of phase and the CDS are lagging the gold prices in the time scales of 64-96 days between 2013 and 2014. Equally, the arrows, ↗, reveal that the gold prices are lagging and receiving cyclical effects stemming from the CDS prices over 24–64, 64–256, and 64–128-day cycles during late 2011 and end of 2012, between mid-2015 and mid-2016, and between 2018-2019, respectively. As depicted in the bottom panel, the gold and stock prices are out-of-phase and the direction of the correlation is negative between early 2014 and mid-2014 over 32-64 days cycle. Further, the arrows are pointed to the left and down, ↙, and suggest that the variables are in phase and the gold prices are leading the stock prices during mid-2015 and early 2017 in the time scales of 16-64 days. However, the stock prices and gold prices are out of phase and the former is leading with cyclical impacts on the latter variable between mid-2015 and mid-2016 and late 2019 in the time scales of 16-32 days. Our results are consistent with the empirical evidence reported in Dahir et al. (2018) for the BRICS countries and in Tiwari et al. (2015) for India.

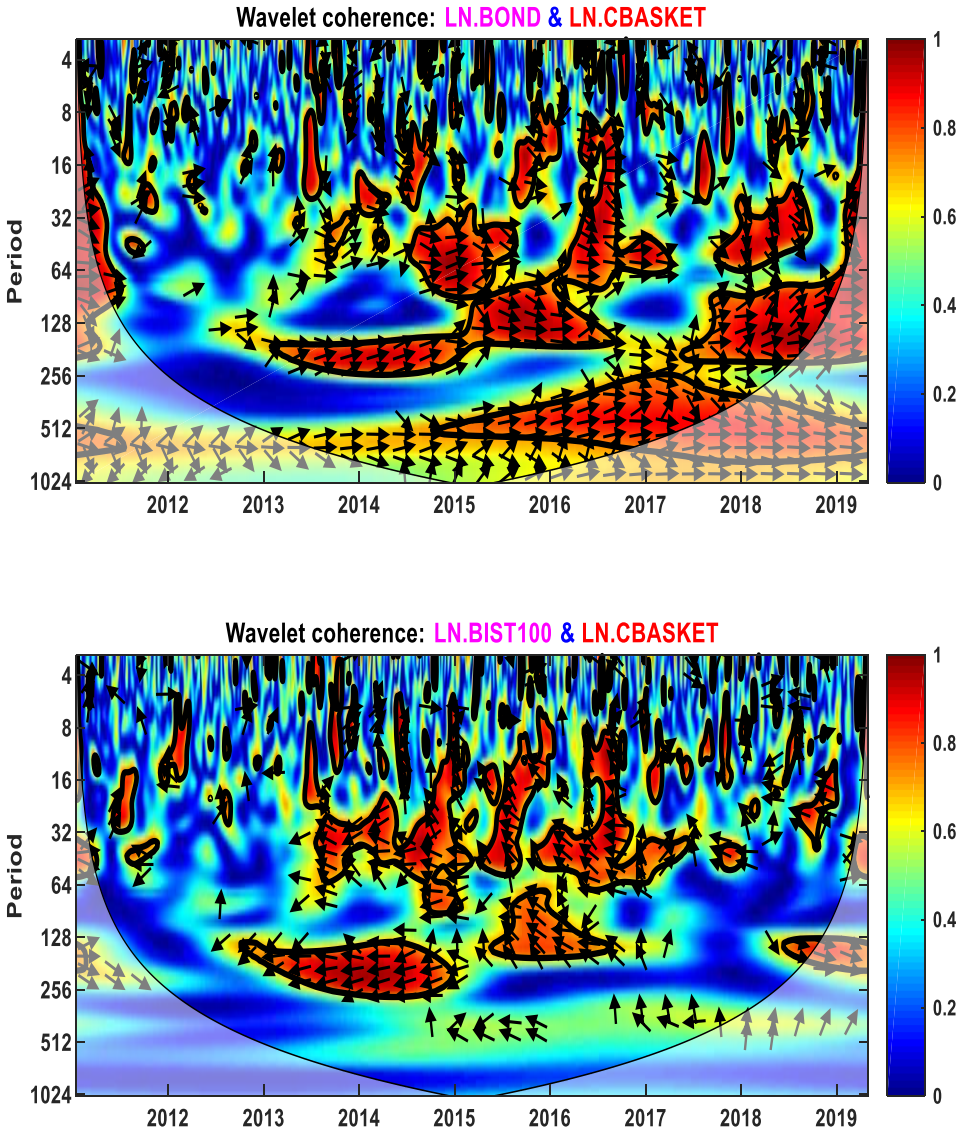

Figure 1. Wavelet coherence between "bond yields – currency basket" and "stock prices – currency basket"

Note: Each red island represents the significance at the 5% level. The direction of the relationship is represented by the orientation of arrows. For details, see the "Methodology" section.

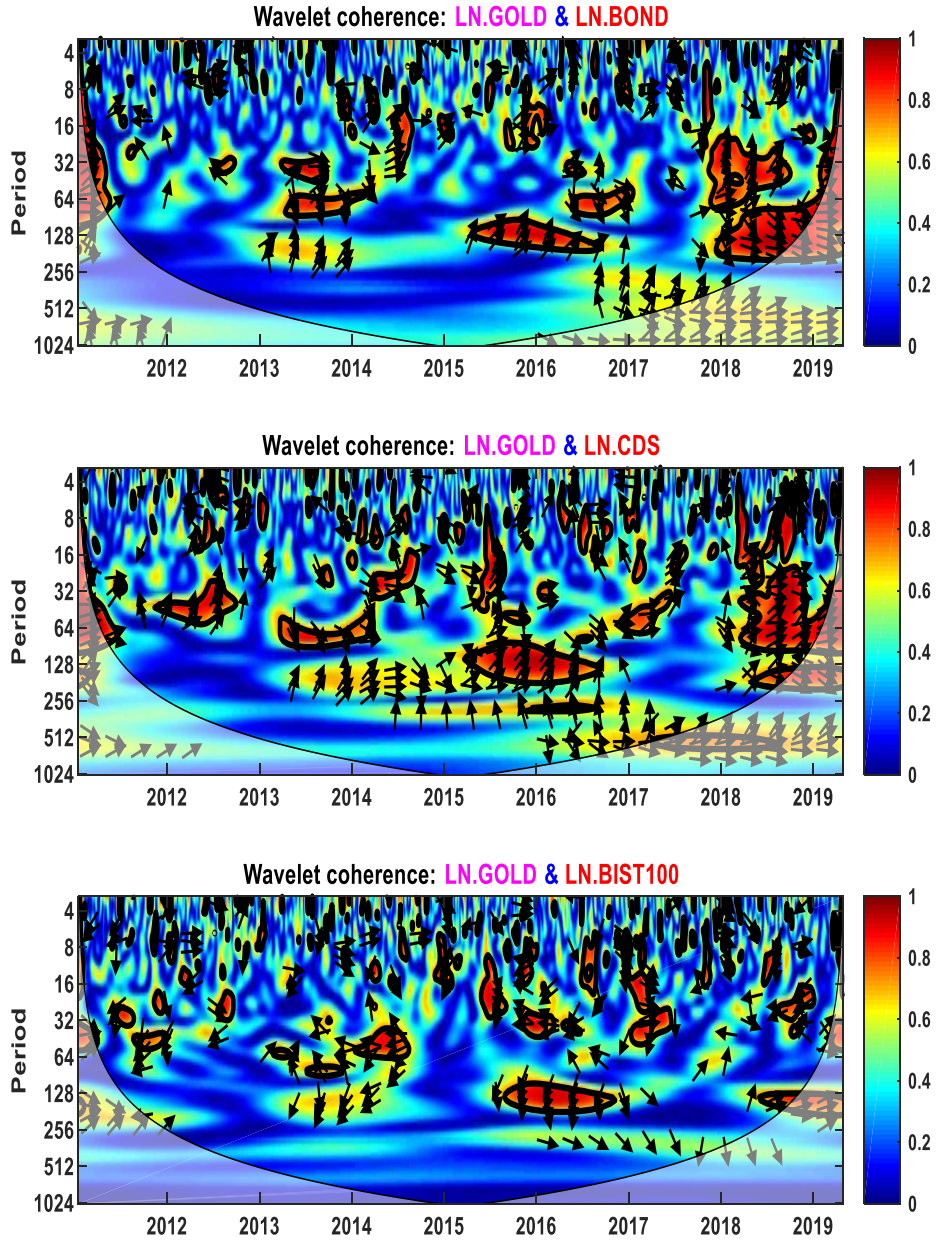

Figure 2. Wavelet coherence between "gold prices – bond yields", "gold prices – CDS", and "gold prices – Bist100"

Note: Each red island represents the significance at the 5% level. The direction of the relationship is represented by the orientation of arrows. For details, see the "Methodology" section.

Table 5. Hafner and Herwartz (2006) causality-in-variance test

Dependent/Independent	DL_BOND	DL_CDS	DL_BIST100	DL_CBASKET	DL_GOLD
DL_BOND		0.381	0.433	1.178	1.822
DL_CDS	11.075***		4.582	1.16	1.764
DL_BIST100	5.586*	2.141		3.339	2.507
DL_CBASKET	169.501***	66.348***	47.519***		7.632**
DL_GOLD	53.72***	45.047***	15.182***	15.776***	

Note: *, **, or *** indicate significant causality-in-variance at the 10%, 5%, or 1% level of significance, respectively. The upper triangular shows, for example, the causality relationship running from "DL_CDS" to "DL_BOND" [0.381] whereas the bottom panel shows the reverse causality.

Table 5 provides the empirical findings of the causality-in-variance test proposed by Hafner and Herwartz (2006) among the first-difference data. Our findings reveal unidirectional causalities among our variables, with exceptions for the pairs of "DL_BIST100~DL_CDS" with no causality relations and "DL_GOLD~DL_FX" with bidirectional causal linkages. In other words, the changes in bond rates unidirectionally Granger-causes the movements in the CDS, stock prices, currency basket rates, and gold prices. Further, the volatility of currency basket and gold prices are caused by the volatility of CDS and stock prices during the sample period. Our findings are in agreement with the results from Delis and Mylonidis (2014) with "Bond⇒CDS" in Italy; from Kim (2003) and Yıldız (2014) with "Bond⇒Stock" in the US and Turkey; from Gün et al. (2016) and Zhang et al. (2010) with "CDS⇒Exchange Rate" in Turkey and the US; from Smith (2001) with "Stock⇒Gold" in the US. However, they contradict Özpınar et al. (2018) with "Bond⇔Exchange Rate" for Turkey; Yıldız (2014) with "Bond⇏Gold" for Turkey; Şahin and Özkan (2018) with "CDS⇔Stock" for Turkey; Akkaya (2017) with "Gold⇒CDS" for Turkey and Yıldız (2014) with "Gold⇒Exchange Rate" for Turkey.

CONCLUSION

In this paper, we investigate the co-movement and causal associations among BIST100, CDS, gold prices, exchange (currency basket), and interest rates in Turkey. Using daily observations, the paper reveals the following empirical results. First, all variables are found to stationary in first log-difference. Second, our paper provides evidence of significant long-run relationships in thirteen out of twenty pairs of variables. Third, the findings of the VECM test reveal two bidirectional and five unidirectional causalities in the short-run; one two-way and six one-way causalities in the long-run among variables, i.e. there exists short-run unilateral and two-way causality relationship between CDS spreads and stock prices. Fourth, the results of wavelet coherence analysis show that all variables correlate negatively with stock prices, as expected, and correlate positively with each other at varying magnitudes and significance levels. Besides, the BIST100

index unidirectionally leads currency basket in the time scale of 16-128 days between 2013-2017 years. Lastly, there exist unidirectional causal linkages among changes in prices for all the pairs of variables, except for BIST100-CDS with noncausality and gold-currency basket with two-way causality. These results, in overall, confirm the validity of the stock-oriented theory, dividend discount model, and the structural model.

Our findings have significant implications for portfolio and risk management and financial stability. Knowing the nature of the relationship among macroeconomic and financial variables could offer significant insights for investors in building portfolio and risk management strategies and for regulatory authorities in constructing monetary policies.

From the portfolio and risk management point of view, the WTC-based results suggest portfolio managers and investors with medium and long-term investment horizons using the stock market as a hedge against other markets and vice versa due to the evidence of negative association intensifying around medium and higher wavelet scales. Further, all variables except stock prices could be seen as a diversifier because of the evidence of positive relationships among these variables. The findings of the causality-in-variance test show that current movements in interest rate could be used to predict future fluctuations in CDS, stock, exchange rate, and gold markets. Besides, the movements in the exchange rate and the gold market might be predicted using the information of the CDS market. On the other hand, the stock market in Turkey is a good indicator of predicting future exchange rates and gold market movements. Lastly, our paper reveals evidence of the usefulness of the exchange rate in predicting gold prices and vice versa. From the policy-making standpoint, on the other hand, policy-makers should take into account time-frequency domain linkages and avoid interrupting foreign exchange rate and bond markets to stabilize the volatilities in these markets since they have significant consequences on the efficiency, resiliency, and soundness of the financial system in Turkey.

In this paper, we did not study the asymmetric or nonlinear relationship and ignore the effect of the crisis on the strength and direction of the relationship. We can conclude that this deficiency warrants future work.

REFERENCES

Akkaya, M. (2017). Türk tahvillerinin CDS primlerini etkileyen içsel faktörlerin analizi [Analysis of internal factors affecting CDS premiums of Turkish treasuries]. *Maliye ve Finans Yazıları, 1*(107), 130-145.

Aksoylu, E. and Görmüş, Ş. (2018). Gelişmekte olan ülkelerde ülke riski göstergesi olarak kredi temerrüt swapları: asimetrik nedensellik yöntemi [Credit default swaps as an indicator of sovereign risk in developing countries:

asymmetric causality method]. *Ekonomik ve Sosyal Araştırmalar Dergisi, 14*(1), 15-33.

Aktug, R. E., Vasconcellos, G. and Bae, Y. (2012). The dynamics of sovereign credit default swap and bond markets: empirical evidence from the 2001 to 2007 period. *Applied Economics Letters, 19*(3), 251-259.

Aloui, C., Jammazi, R., & Hamida, H. B. (2018). Multivariate co-movement between Islamic stock and bond markets among the GCC: a wavelet-based view. *Computational Economics, 52*(2), 603-626.

Altarturi, B. H., Alshammari, A. A., Saiti, B., & Erol, T. (2018). A three-way analysis of the relationship between the USD value and the prices of oil and gold: A wavelet analysis. *AIMS Energy, 6*(3), 487.

Andrieş, A. M., Ihnatov, I. and Tiwari, A. K. (2014). Analyzing time–frequency relationship between interest rate, stock price and exchange rate through continuous wavelet. *Economic Modelling, 41*, 227-238.

Arouri, M. E. H., Lahiani, A. and Nguyen, D. K. (2015). World gold prices and stock returns in China: insights for hedging and diversification strategies. *Economic Modelling, 44*, 273-282.

Balı, S. and Cinel, M. (2011). Altın fiyatlarının İMKB 100 Endeksi'ne etkisi ve bu etkinin ölçümlenmesi. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi, 25*(3-4), 45-63.

Başarır, Ç. and Keten, M. (2016). Gelişmekte olan ülkelerin CDS primleri ile hisse senetleri ve döviz kurları arasındaki kointegrasyon ilişkisi [A cointegration analysis between CDS premiums, stock indexes and exchange rates in emerging countries]. *Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 8*(15), 369-380.

Baur, D. G. and Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review, 45*(2), 217-229.

Bhunia, A. (2013). Cointegration and causal relationship among crude price, domestic gold price and financial variables: an evidence of BSE and NSE. *Journal of Contemporary Issues in Business Research, 2*(1), 1-10.

Chkili, W. (2016). Dynamic correlations and hedging effectiveness between gold and stock markets: evidence for BRICS countries. *Research in International Business and Finance, 38*, 22-34.

Ciner, C., Gurdgiev, C. and Lucey, B. M. (2013). Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates. *International Review of Financial Analysis, 29*, 202-211.

Dahir, A. M., Mahat, F., Ab Razak, N. H. and Bany-Ariffin, A. N. (2018). Revisiting the dynamic relationship between exchange rates and stock prices in BRICS countries: A wavelet analysis. *Borsa Istanbul Review, 18*(2), 101-113.

Delis, M. D. and Mylonidis, N. (2011). The chicken or the egg? A note on the dynamic interrelation between government bond spreads and credit default swaps. *Finance Research Letters, 8*(3), 163-170.

Dornbusch, R. (1976). Expectations and exchange rate dynamics. *Journal of Political Economy, 84*(6), 1161–1176.

Dornbusch, R. and Fisher, S. (1980). Exchange rates and the current account. *American Economic Review, 70*(5), 960-971.

Elmas, B. and Polat, M. (2014). Altın fiyatlarını etkileyen talep yönlü faktörlerin tespiti: 1988-2013 dönemi [Determination Demand Faktors of Affecting Gold Price: Period 1988-2013]. *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi, 15*(1), 171-187.

Flannery, M. J. and James, C. M. (1984). The effect of interest rate changes on the common stock returns of financial institutions. *The Journal of Finance, 39*(4), 1141-1153.

Forte, S. and Pena, J. I. (2009). Credit spreads: An empirical analysis on the informational content of stocks, bonds, and CDS. *Journal of Banking & Finance, 33*(11), 2013-2025.

Frankel, J. A. (1984). Tests of Monetary and Portfolio Balance Models of Exchange Rate Determination. John Bilson and Richard Marston (Eds.) eds., In *Exchange Rate Theory and Practice*, Chicago: University of Chicago Press for NBER, (pp.239-260).

García, M. M., Valle, C. T. and Marín, J. L. M. (2014). Sovereign bond spreads and credit default swap premia: cointegration and causality. *Investment Management and Financial Innovations, 11*(2), 47-59.

Granger, C. W., Huangb, B. N. and Yang, C. W. (2000). A bivariate causality between stock prices and exchange rates: evidence from recent Asian flu. *The Quarterly Review of Economics and Finance, 40*(3), 337-354.

Grinsted, A., Moore, J. C. and Jevrejeva, S. (2004). Application of the cross wavelet transform and wavelet coherence to geophysical time series. *Nonlinear Processes in Geophysics, 11*(5/6), 561-566.

Gün, M., Kutlu, M. and Karamustafa, O. (2016). Gezi parkı olaylarının Türkiye kredi temerrüt swapları (CDS) üzerine etkisi [The Effects of Gezi Park Protests on Turkey's Credit Default Swaps (CDS)]. *Journal of Business Research Turk*, 557-575.

Hacker, R. S., Karlsson, H. K. and Månsson, K. (2014). An investigation of the causal relations between exchange rates and interest rate differentials using wavelets. *International Review of Economics & Finance, 29*, 321-329.

Hafner, C. M. and Herwartz, H. (2006). A Lagrange multiplier test for causality in variance. *Economics letters, 93*(1), 137-141.

Hatemi-J, A. (2008). Tests for cointegration with two unknown regime shifts with an application to financial market integration. *Empirical Economics, 35*(3), 497-505.

Ingalhalli, V. and Reddy, Y. V. (2016). A study on dynamic relationship between oil, gold, forex and stock markets in Indian context. *Paradigm, 20*(1), 83-91.

Jain, A. and Biswal, P.C. (2016). Dynamic linkages among oil price, gold price, exchange rate, and stock market in India. *Resources Policy, 49*, 179-185.

Jarrow, R. A. and Yu, F. (2001). Counterparty risk and the pricing of defaultable securities. *The Journal of Finance, 56*(5), 1765-1799.

Kim, K. H. (2003). Dollar exchange rate and stock price: evidence from multivariate cointegration and error correction model. *Review of Financial economics, 12*(3), 301-313.

Le, T. and Chang, Y. (2016). Dynamics between strategic commodities and financial variables: evidence from Japan. *Resources Policy, 50*, 1-9.

Lee, J. and Strazicich, M. C. (2003). Minimum Lagrange multiplier unit root test with two structural breaks. *The Review of Economics and Statistics, 85*(4), 1082-1089.

Longstaff, P. F., Mithal, S. and Neis, E. (2003). The credit-default swap market: is credit protection priced correctly? Working Paper, Anderson School, UCLA, August, 1-31.

Malhotra, J. and Corelli, A. (2018). The determinants of CDS spreads in multiple industry sectors: a comparison between the US and Europe. *Risks, 6*(3), 89.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. *The Journal of finance, 29*(2), 449-470.

Norden, L. and Weber, M. (2009). The co-movement of credit default swap, bond and stock markets: An empirical analysis. *European financial management, 15*(3), 529-562.

Özpınar, Ö., Özman, H. and Doru, O. (2018). Kredi temerrüt takası (CDS) ve kur-faiz ilişkisi: Türkiye örneği [Credit Default Swap (CDS) & The Link Between Currency And Interest Rate: Turkey]. *Bankacılık ve Sermaye Piyasası Araştırmaları Dergisi, 2*(4), 31-45.

Şahin, E. E. and Özkan, O. (2018). Kredi temerrüt takası, döviz kuru ve Bist100 Endeksi İlişkisi [Credit Default Swap, Exchange Rates and BİST100 Index Relationship: Cointegration and Causality Analysis]. *Hitit Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 11*(3), 1939-1945.

Sakti, M. R. P., Masih, M., Saiti, B., & Tareq, M. A. (2018). Unveiling the diversification benefits of Islamic equities and commodities. *Managerial Finance, 44*(6), 830-850.

Shahzad, S. J. H., Aloui, C., & Jammazi, R. (2020). On the interplay between US sectoral CDS, stock and VIX indices: Fresh insights from wavelet approaches. *Finance Research Letters, 33*, 101208.

Smith, G. (2001). The price of gold and stock price indices for the United States. *The World Gold Council, 8*(1), 1-16.

Tiwari, A. K., Bhanja, N., Dar, A. B. and Islam, F. (2015). Time–frequency relationship between share prices and exchange rates in India: Evidence from continuous wavelets. *Empirical Economics, 48*(2), 699-714.

Tokat, H. A. (2013). Altın, döviz ve hisse senedi piyasalarında oynaklık etkileşimi mekanizmasının analizi [Volatility interaction mechanism among the gold, foreign exchange and equity markets]. *İstanbul Üniversitesi Siyasal Bilgiler Fakültesi Dergisi, 48*, 151-162.

Toraman, C., Başarır, Ç. and Bayramoğlu, M. F. (2011). Altın fiyatlarını etkileyen faktörlerin tespiti üzerine: MGARCH modeli ile bir inceleme [Determination of factors affecting the price of gold: a study of MGARCH model]. *Uluslararası Alanya İşletme Fakültesi Dergisi*, *3*(1), 1-20.

Torrence, C. and Webster, P. J. (1999). Interdecadal changes in the ENSO–monsoon system. *Journal of Climate, 12*(8), 2679-2690.

Yıldız, A. (2014). BIST100 endeksi ile alternatif yatırım araçlarının ilişkisi [The relationship between Bist100 index and alternative investment instruments]. *SDÜ İİBF Dergisi, 19*(2), 39-56.

Zhang, G., Yau, J. and Fung, H. G. (2010). Do credit default swaps predict currency values?. *Applied Financial Economics, 20*(6), 439-458.

Živkov, D., Njegić, J. and Pećanac, M. (2019). Wavelet analysis of the interdependence between stocks and bonds in the selected East European and Eurasian emerging markets. *Ekonomický Časopis (Journal of Economics), 67*(2), 175-194.