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Greek government-debt crisis events and European financial markets: News surprises on Greek bond yields and inter-relations of European financial markets

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Abstract

We study the impact of Greek government-debt crisis events on inter-relations of European financial markets during the European sovereign debt crisis. To this end, we examine the effects of three categories of Greek government-debt crisis events in the realized correlations and correlation jumps of government bonds, CDS, and stock indices of seven European countries (i.e., France, Germany, Greece, Ireland, Italy, Portugal, and Spain) via the respective dummy variables and news surprises on 2-year, 5-year, and 10-year government bonds and CDS in a non-parametric framework by employing Tobit regression models. According to the results, the direction of most impacts on correlations and correlation jumps is negative, suggesting that the Greek government-debt crisis events reduced the homogeneity among member states in the Eurozone. We also investigate the types of Greek government-debt crisis events that have the highest impacts on correlations and correlation jumps and find that the highest impacts mainly result from news originating from Greek and European sources.

Keywords: Contagion; Greek debt crisis; realized correlation; correlation jumps.

JEL classifications: E44, G14, G01, C22, G28.

Declarations of interest: None.

Data Availability Statement: Data available on request due to privacy/ethical restrictions.

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1 Introduction

The Greek sovereign debt crisis has drawn substantial attention, since the contagion from the Greek crisis started spreading across Europe in 2010, as evidenced by, e.g., the widening Euro area sovereign Credit Default Swap (CDS) and bond yield spreads compared to German bonds, the fall in the Euro against major currencies, and the fall in equity markets (Katsimi and Moutos, 2010). Historically, among EU countries, Greece has been running mostly significant current account imbalances.[1] But the main drivers that led to placing Greece in the center of the European sovereign crisis are the following four: a) accumulated loss of economic competitiveness (fast domestic inflation and unit labor cost growth), b) pronounced fiscal policy relaxation following the Euro adoption (resulting in boosted consumption and reduced private savings), c) domestic financial deepening and accelerated EU convergence after the Euro adoption (leading to acute external imbalances and denials of external financing), and d) cyclical influences (faster GDP growth).[2] Yet, continued vigilance, wage policies, and the reforms program resulted in an excessive widening of the current account deficit, justified by domestic economic fundamentals.

Going back to the time of Greece's admission in the Euro area, it became clear that public finances in Greece were unsustainable (de Haan et al., 2015), especially after several revisions of previously published deficit values. The initial phase of the crisis was dominated by Greece's lack of budgetary discipline (Lane, 2012). These budgetary problems, in accordance with very loose financial conditions and macroeconomic and financial imbalances in other European countries, triggered the European sovereign debt crisis. At the same time, there were no strong incentives for member states to prevent other member states from deviating from the objective to strive for a balanced budget in the medium term. In addition, the effectiveness of Stability Programs was not sufficient, and the core European economies did not perform much better in terms of deficit. Greece exerted influence on the sovereign bond yields of other highly indebted countries in the Economic and Monetary Union (EMU) periphery. This adheres to the so-called "wake-up call" view (Mink and de Haan, 2013). On 10th May 2010, the ten-year yield spread between Greek and German government bonds reached about 1,000 basis points. This was the start of the crisis for Ireland, Portugal, and, later, Spain and Italy. The interest spreads on government bonds of countries that came to be known as GIIPS did not only reflect increased credit risk but also doubts about the sustainability of the EMU. When the Euro sovereign debt crisis erupted, problems were amplified by the fact that the architecture of the EMU did not contain provisions for the resolution of such a crisis.

Since the European crisis started, the European Central Bank's (ECB) actions have changed a lot. Part of the literature suggests that monetary policy played an important role in creating the crisis by too low-interest rates for an extended period of time (Taylor, 2009), which fueled an asset price boom and spurred financial intermediaries to increase leverage and take on excessive risks (Borio and Zhu, 2008). As the financial crisis deepened, the first reactions of central banks were, as expected, to cut interest rates. After these

[1] According to the Bank of Greece's balance of payments, the deficit from €10.6bn (7.8% of GDP) in 2000 reached a record high of €34.8bn (14.9% of GDP) in 2008, turning into a surplus of €1.2bn (0.7% of GDP) in 2013.

[2] A detailed presentation of the Greek financial crisis can be found in, e.g., Gibson et al. (2012).

reactions, quantitative easing (QE), forward guidance, and macro-prudential measures followed, as a step further. Blinder et al. (2017) found that since the European debt crisis, central bankers have been generally less eager than academics to permanently adopt changes in monetary policy as a response to the recent debt crisis. The central bank communication has also been altered for the ECB. It has become more frequent since the crisis, while the most popular form of this forward guidance is purely qualitative, as a policy and a communication tool. In terms of quality, the ECB needed to explain its novel policies more comprehensively than ever before. The crisis, the deployment of unconventional monetary policies, and the broader (sometimes tacit) mandates made discussions surrounding the actions of monetary policy committees more controversial than ever. In terms of frequency, the ECB has aired substantially more internal disagreement since the crisis. Its earlier principle of one-voice communication was seriously challenged, in light of the considerable disagreement among its Governing Council members. Therefore, it started releasing more regular accounts of monetary policy discussions from January 2015, compared to the infrequent one-voice statements.

Although it is economies that are more directly affected by policy actions[3], ECB monetary policy actions and communications have affected financial markets as well. Specifically, ECB's QE significantly lowered yields (Altavilla et al., 2015). Similarly, the literature on the effect of such communications in financial markets mostly indicates declining yields as a result of announcements of purchase programs. For instance, announcements about the ECB's Securities Market Program (SMP) in 2010 affected yields of the five targeted Euro area countries (Eser and Schwaab, 2016). In July 2012, ECB President Mario Draghi's strong statement and the subsequent announcement of the ECB's Outright Monetary Transactions (OMT) Program calmed financial markets, without any funding being necessary. Moreover, the announcement of the ECB's purchases program in 2014 reduced sovereign yields on long-term bonds while also raising share prices of banks (Andrade et al., 2016).

The Greek sovereign debt crisis and ECB monetary policy have been widely discussed in the literature.[4] Nevertheless, as the Greek sovereign debt crisis rapidly turned into a Euro area crisis (Kosmidou et al., 2015), and as the ECB failed to promptly signal to the financial markets that the Greek government debt would be eligible for servicing as collateral in the provision of liquidity, a question that remains underexplored is to what extent Greek government-debt crisis events affect other European financial markets. The importance of studying the impact of the Greek sovereign debt crisis is revealed by the fact that the EMU authorities started reforming the Eurozone's institutional infrastructure after the Greek debt crisis started (in May 2010). Motivated by the above as well as the efficient market hypothesis, according to which asset prices reflect all available information and markets adjust rapidly to new information, this paper aims to study the Greek sovereign debt crisis in terms of its reflections in co-movements of the financial markets of the most important Eurozone economies. More specifically, this study examines whether Greek government-debt crisis events affecting the Greek economy also affect the realized correlations and correlation jumps of the 2-, 5-, and 10-

[3]Indeed, in the absence of the first round of QE, real GDP and core CPI in the Euro area would have been 1.3% and 0.9%, respectively, lower (Wieladek and Pascual, 2016).

[4]See, e.g., Katsimi and Moutos (2010), Gibson et al. (2012), Cukierman (2013), Mink and de Haan (2013), Bhanot et al. (2014), Ricci (2015), Kosmidou et al. (2015), and Kousenidis (2017), among others.

year government bonds, CDS, and stock indices of seven European countries, some of which faced significant fiscal instability during the European sovereign debt crisis.[5] We therefore aim to contribute to the literature on the impact of the Greek sovereign debt crisis on the interconnectedness between financial markets. To the best of our knowledge, this is the first study to investigate the effects of Greek government-debt crisis related events in the correlations and jumps of correlations between European financial markets. In our study, the homogeneity of Eurozone financial markets is also assessed.

As will be shown, the direction of most impacts of news and news surprises on correlations and correlation jumps is negative. Practically, this means that the Greek government-debt crisis events reduced the homogeneity among member states in the Eurozone. In addition, for most of the European countries considered in this study, the highest impacts on correlations and correlation jumps result from news originating from Greek and European sources. Our findings provide improved insights into the link between Greek instability events and European financial markets and, hence, improve our understanding of the contagion during the European sovereign debt crisis.

The remainder of this paper is organized as follows: Section 2 reviews related literature. Section 3 discusses the data used in this study. In Section 4, the employed methodologies are deployed. In Section 5, our empirical results are discussed. Finally, in Section 6, the concluding remarks and the major policy implications are outlined.

2 Related studies

This section reviews relevant literature. We first review studies on the effects of economic news in financial markets, especially during or following the recent financial crisis. We then review key studies in the existing realized correlation literature for analyzing contagion in financial markets.

2.1 Economic news and financial markets

Over the last few decades, the impact of economic news and announcements on asset prices has received much attention in the literature. In an early study, Fama et al. (1969) investigated the process by which stock prices adjust to information. Later, Pearce and Roley (1983, 1985), Boyd et al. (2005), Nikkinen et al. (2006), Chulia et al. (2010), and Tang et al. (2013) examined stock markets' reaction to economic news, while Balduzzi et al. (2001), Green (2004), and Christiansen and Ranaldo (2007) studied the impact of economic news on bond prices. More recently, Liu et al. (2017) investigated the effect of economic policy uncertainty in future volatility.

In the last decade, several studies have also investigated such impacts on financial markets during or following the recent financial crisis. For example, Cheung et al. (2019) studied the exchange rate effects

[5]Similar to Beetsma et al. (2017) and Bratis et al. (2017), the European countries considered in this study include both northern European countries, namely France and Germany, and the more financially distressed European countries, i.e. Greece, Ireland, Italy, Portugal, and Spain.

of macro news before, during, and after the global financial crisis and found that, while US macro news is now more important than before the crisis, the effect of Japanese macro news has declined to the point of near-irrelevance. However, there has been a particular focus in the literature on European financial markets, since the recent crisis has resulted in large movements in the sovereign bond yields of Eurozone countries (Beetsma et al., 2017). For instance, Apergis et al. (2016) explored how newswire messages, revealed by statements recorded by newspaper articles, impacted CDS spillovers across Greece, Ireland, Italy, Portugal, and Spain (GIIPS) during the European debt crisis and showed that news created significant spillover effects across the underlined CDS markets, while Falagiarda and Reitz (2015) studied the effects of ECB news about unconventional monetary policy operations in the sovereign spreads of GIIPS relative to Germany and found that the ECB announcements about unconventional monetary policies decreased long-term government bond yield spreads relative to German counterparts in all of the considered countries, apart from Greece.

In addition, as yields tend to change in the same direction but at times change in opposite directions, especially between northern European countries and more financially distressed countries in Europe, including GIIPS (Beetsma et al., 2017), some studies have considered both northern European countries and European financially distressed countries in their analyses comparing the results. For instance, Caporale et al. (2016) examined the impact of newspaper coverage of macro news on stock returns in Belgium, France, Germany, and GIIPS, and found that markets are particularly responsive to negative news, with the reaction being larger in the more financially distressed countries and during the recent crisis period. Moreover, Bratis et al. (2017) investigated the effects of the EMU's announcement of a Financial Transactions tax on bond and equity volatilities for France and Germany, defined as core EMU countries, as well as GIIPS, defined as periphery EMU countries, and found that the announcement effect of the Financial Transactions tax increased the volatility of both core EMU's equity portfolio and periphery EMU's bond portfolio. On the other hand, Beetsma et al. (2017) found that more news tends to increase the volatility of yields of financially distressed countries but to lower the covariance of distressed countries' yields with German bond yields.

Furthermore, Kosmidou et al. (2015) and Kousenidis (2017) examined the impact of the European Union (EU), ECB, and International Monetary Fund (IMF) news on the Greek stock market and on crisis-affected countries, respectively. As for the impact of the Greek sovereign debt crisis, in particular, on financial markets, Kosmidou et al. (2015) studied the effect of Greek economic news releases in the return and risk of the Greek stock market, whereas Bhanot et al. (2014) studied the effect of changes in Greek sovereign yield spreads in abnormal returns of financial sector stocks for specific Eurozone countries and found that during the Greek debt crisis increases in yield spreads were linked to negative abnormal returns on financial stocks in Portugal, Spain, and the Netherlands. However, no previous study has explored the impact of Greek government-debt crisis related events on the correlations or correlation jumps between European financial markets.

2.2 Realized correlation analysis of contagion

Turning our attention to contagion, it should be noted that it is a key factor for understanding the transmission channels of a crisis (Gkillas et al., 2019). However, contagion has a broad meaning varying with regard to its definition (see Periocoli and Sbracia, 2003). As a result, in the existing literature, there are several approaches to estimating contagion. A common approach is through the estimation of correlations, either parametrically or non-parametrically. The best parametric estimation method of correlations is the DCC-GARCH model. Nevertheless, as noted by McAleer (2019), there is strong criticism of the DCC model involving algebraic non-existence, mathematical irregularity, and non-asymptotic properties (see also Bouri et al., 2020). On the other hand, realized correlation measuring, a non-parametric estimation method, constitutes one of the most convenient and powerful approaches for efficiently incorporating intra-day data to multivariate volatility estimation and forecasting. Indeed, the correlation literature has paid a lot of attention to realized covariances and correlations since Andersen et al. (2001a) and Andersen et al. (2001b) established the realized correlation measure. Realized correlations are considered as unconditional, without any assumptions, measures of latent correlations (see Gkillas et al., 2018), with the realized correlation coefficient approximating directly the asymptotic distribution of the correlation (Barndorff−Nielsen and Shephard, 2004). Moreover, realized correlations are constructed as quotients between realized covariances and products of realized standard deviations, which significantly improve the accuracy and performance of trading strategies and risk measures (Audrino and Corsi, 2010). After the estimation of realized correlations, low-parameterized and mostly linear models can predict realized correlations both in-sample and out-of-sample.[6]

Nevertheless, correlation series have been challenged on grounds of whether they are continuous processes or not. The literature should place more emphasis on jumps (as breaks or discontinuities) in such sequential movements between two time series, given that the presence of breaks reduces the accuracy of any model in terms of estimation, prediction, and forecasting of correlations[7] and has important implications for risk management, diversification benefits, and asset allocation. Yet, Butler and Joaquin (2002) highlighted that contagion, as a significant change in correlation properties (i.e. correlation jumps), differs depending on the direction of shocks.

However, the effect of news releases in realized correlations and correlation jumps has been rather underexplored in the existing literature. Studies that have used realized volatility and correlations to assess the impact of economic announcements on economic and financial indicators include those of Wang et al. (2008) and Chulia et al. (2010), while Christiansen and Ranaldo (2007) studied the impact of economic news on realized variances and realized correlations of bond and stock returns and Chatrath et al. (2014) investigated the impact of macro news on currency jumps and co-jumps[8]. Furthermore, Beetsma et al. (2017) examined

[6] In contrast, in the case of parametric or semi-parametric correlation estimation, heavily parameterized models such as the DCC-GARCH (see Missio and Watzka, 2011; Aielli, 2013), BEKK (Engle and Kelly, 2012), and Markov-Switching Vector Autoregressive (VAR) models (see, e.g., Casarin et al., 2018) are useful for prediction but not for estimation purposes.

[7] This is enforced by considering that most of such models assume Gaussian conditional distributions.

[8] It is worth noting that, although both jumps and co-jumps target at revealing the breaks in the relation of two assets' volatilities, the two are different. Co-jumps refer to the synchronous jumps in the volatility series of two assets. The notion, limiting theory, and discrete sample properties of co-jumps were first researched by Novotny and Urga (2018).

the impact of news and the Securities Markets Programme in the Eurozone on realized variances during the European debt crisis. On the other hand, Ait-Sahalia and Xiu (2016) studied the informational content of jumps and co-jumps and pointed out that they often occur in response to the resolution of policy uncertainty. This was a further strong motive for our study to research the impact of news/events of the Greek sovereign debt crisis on Eurozone financial markets' correlations and correlation jumps.

In the context of our analysis, contagion between two time series is thus depicted by estimating the realized correlation and correlation jumps between these series. A significant jump found in a realized correlation series will therefore have a direct effect in the degree of contagion. In our study, for such an effect, two correlation jump detection schemes are employed, both of which are based on the detection method of Bekaert and Hoerova (2014) for volatility. More specifically, the first scheme is based on the realized threshold bi-power variation correlation and the second one is based on the median realized correlation. We employ the range-based realized correlation, which is based on the co-range estimate of the covariance (as introduced by Bannouh et al., 2009). Moreover, although Lahaye et al. (2011) used Tobit-GARCH and Probit models to explore the impact of US macroeconomic announcements on jumps and co-jumps in equity, bond, and foreign exchange markets, where jumps were detected via the Lee and Mykland (2008) detection scheme, in our study we extend the model of Lahaye et al. (2011) by using the Tobit-RC and Tobit-RCJ models for correlations and correlation jumps, respectively. Moreover, the estimation of the co-movement responses is done simultaneously in a univariate framework, so that a unified framework is employed and any possible bias is avoided when two or more announcements occur within the same time interval (see Hardouvelis, 1988).

3 Data

In our study, the effect of Greek government-debt crisis events in EMU realized correlations and correlation jumps is assessed via dummy variables and news surprises. For the former assessment, events are split into three categories based on the official sources from which news was derived. The first category refers to news coming from Greece, e.g., from the Greek Prime Minister, Minister of Finance, Bank of Greece, Hellenic Statistical System and Hellenic Statistical Authority, Greek Parliament, Athens Exchanges Group, etc. The second category refers to news coming from Europe, e.g., from the European Central Bank, Ecofin, European Commission, all organizations of the European Union (such as the EMU), Eurostat, and European Heads of countries (like Merkel, Trische, Shaeuble, and Strauss-Kahn). The third category includes news coming from international sources, e.g., from Fitch, Standard & Poors, Moodys's, non-European Heads of countries, and the IMF. Events are thus classified based on the region from which the event releases that affect the Greek economy originate. Therefore, the first category includes Greek government-debt crisis events that affect the Greek economy coming from Greece itself. The second category concerns Greek government-debt crisis events that affect the Greek economy coming from the Eurozone. The third category includes Greek government-debt crisis events that affect the Greek economy coming from international institutions. The classification of Greek

government-debt crisis events affecting the Greek economy is based on the related literature[9]. Moreover, a fourth category includes all of them. For the latter assessment, events are split into four categories based on the news surprises on 10-year, 5-year, and 2-year Greek government bonds and Greek CDSs. Specifically, we have used each event of news as provided by any of the three categories of official sources that made a change to any of the 10-year, 5-year, or 2-year Greek government bonds or Greek CDSs such that each event/news affected the actual figure of the respective four bond yields. Then, for each of the four categories, the news surprises values are calculated and employed for the aforementioned paper's research scope. The information from the Greek government-debt crisis events affecting correlations and correlation jumps between European financial markets is therefore revealed through either dummy variables (D_1, D_2, D_3, and D_4) on important dates or news surprise variables (SUR_{2Y}, SUR_{5Y}, SUR_{10Y}, and SUR_{CDS}). The first three dummy variables refer to the respective three categories of events, while the fourth one includes all of them. The news surprise variables refer to the swifts of the Greek generic government bonds as well as to CDS. News surprises ($SUR_{i,t}$) are deployed as in Balduzzi et al. (2001), Kurov (2010), Rangel (2011), and Kapetanios et al. (2014), among others, and are calculated as:

$$SUR_{i,t}=\frac{A_{i,t}-E_{i,t}}{\sigma_i} \tag{1}$$

where $A_{i,t}$ denotes the i^{th} event item's actual figure (2-year, 5-year, 10-year, or CDS Greek government bond yield) released at time t, $E_{i,t}$ is the expected value of indicator i based on the Bloomberg median forecast, and σ_i is the sample standard deviation of the surprise component for the i^{th} event item. Standardization helps us compare different event items. The inclusion of the news surprise variables in our study incorporates the events' direction in the analysis.

The European countries considered in this study include both northern European countries, namely France and Germany, and the more financially distressed European countries, i.e. Greece, Ireland, Italy, Portugal, and Spain. The selection of these countries is based on the fact that Germany, France, Italy, and Spain are the four largest member economies, whereas in Europe's geographical periphery, Greece, Ireland, and Portugal have been characterized as fiscally vulnerable. Indeed, the core Euro area countries, like France, Germany, Spain, and Italy, were in a position to borrow from the rest of the world, and on-lend to Greece, Portugal, and other Eurozone countries, whereas countries like Greece and Portugal, had widened current account deficits.[10]

The sample period starts on 1st July 2009 when the Bank of Greece's statistical bulletin showed that the central government deficit for the 6 months was high enough at 7.5% of GDP ($17.9 bn), and ends on 1st

[9] Papers mentioned in the previous section as well as Jiang et al. (2012) and Kutan et al. (2012), among others.

[10] It is worth noting that in the turn of 2008, the current account deficits/surpluses were: -14.9% (Greece), -12.6% (Portugal), -9.6% (Spain), -3.3% (France), -2.9% (Italy), and +6.2% (Germany). The difficulties in reducing large deficits, in a low growth and inflation environment, challenged the soundness of European states' balance sheets. Moreover, the low spreads on sovereign debt indicated that markets did not expect substantial default risk and certainly not a fiscal crisis of the scale that could engulf the Euro system as a whole. For the Euro periphery, the 2008 global financial crisis triggered a major reassessment among investors of the sustainability of rapid credit growth and large (particularly private sector capital) external deficits and the tightening of credit conditions, with national banking systems grappling with the twin problems of rising estimates of loan losses and a liquidity squeeze in funding markets. The combined impact of domestic recessions, banking-sector distress, and the decline in risk appetite among international investors fueled the conditions for a European sovereign debt crisis. The importance of this crisis is evident by the immediate act of the EMU authorities, reforming the Eurozone's institutional infrastructure.

June 2015, i.e. before the imposition of capital controls on banking outflows funds in Greece (see Gkillas et al., 2016). At first, we employ intra-day data to estimate daily realized correlation. Then, we employ daily data to estimate monthly realized correlation jumps.

Table 1 reports the data employed in this study in detail. Panel A depicts the number of events examined in the paper. The events have been retrieved from news providers as released on a daily basis during the period of the analysis. Out of these events, the one hundred thirty-two (132) most influential ones to the Greek economy have been selected.[11] Their selection was made in terms of the significance and magnitude (in swift of bond yield) of their direct effect. More specifically, the Greek government-debt crisis event selection includes all events that had a direct, significant, and measurable (in bond yield swift) effect in the Greek economy. Events coming from other Eurozone countries or international institutions that affected the Greek economy are also included, given that some countries including Greece had their sovereign debt downgraded to junk status by international credit rating agencies during the crisis, worsening investor fears. Panels B, C, and D of Table 1 depict the symbols and description of the data series of the considered countries for the 2-year, 5-year, and 10-year generic government bonds as well as stock indices and CDS, accordingly. The data for the European financial markets were acquired from Datastream.

4 Methodology

This section describes in detail the non-parametric estimators of correlations and correlation jumps and the methodology for revealing the impact of the Greek government-debt crisis events affecting the Greek economy. Correlations and correlation jumps must be accurately estimated. Previous studies on economic announcements are mostly based on a parametric framework. However, a more natural way to estimate these series is non-parametrically, based on the strength of the data. Furthermore, all of the range estimators (even the simple range) are compatible with realized correlation estimators because they use data from a higher sampling frequency without requiring any prior knowledge of all prices from the highest frequency. In addition, the realized range estimator employs data from two frequencies higher than the one employed by volatility estimators.

4.1 Realized correlation

The realized correlation estimator used in this study is based on the co-range estimate of covariance, as introduced by Bannouh et al. (2009). This can be entitled as range-based realized correlation ($RBRC_{t,AB}$) and is equal to the realized co-range estimator of covariance ($CR_{t,AB}$) divided by the square root of the Parkinson range estimator of the two assets under consideration ($Ra_{t,A}, Ra_{t,B}$)[12], as follows:

[11] We provide these Greek government-debt crisis events as supplementary material of this study.

[12] Where the realized range estimator is defined with the use of the daily high and low prices as $Ra_t = \frac{1}{4ln2}\left[ln\left(p_t^h/p_t^l\right)\right]^2$, where p_t^h is the highest price and p_t^l is the lowest price within day t.

$$RBRC_{t,AB}=\frac{CR_{t,AB}}{\sqrt{Ra_{t,A},Ra_{t,B}}}=\frac{\frac{1}{2\lambda_A\lambda_B}\left(Ra_{t,P}-\lambda_A^2 Ra_{t,A}-\lambda_B^2 Ra_{t,B}\right)}{\sqrt{\left(\frac{1}{4ln2}\left[ln\left(p_{t,A}^h/p_{t,A}^l\right)\right]^2\right)\left(\frac{1}{4ln2}\left[ln\left(p_{t,B}^h/p_{t,B}^l\right)\right]^2\right)}} \tag{2}$$

where $CR_{t,AB}$ is the realized co-range estimator of covariance, $Ra_{t,A}$, $Ra_{t,B}$, and $Ra_{t,P}$ are the range estimates of asset A, asset B, and the portfolio, respectively, whereas $p_{t,A}^h$ and $p_{t,B}^h$ are the highest daily prices and $p_{t,A}^l$ and $p_{t,B}^l$ are the lowest daily prices within day t for assets A and B, respectively. According to Brandt and Diebold (2006), λ_A and λ_B are the weights of the two assets in the portfolio (a default choice is 50% in A and 50% in B).

4.2 Correlation jumps

Our study focuses not only on detecting the existence of jumps (as breaks or discontinuities) in a continuous correlation series but also on the magnitude of jumps, revealing the realized breaks (jumps)[13] in correlation series, as detected directly in the correlations. In our study, two correlation jump detection schemes are employed. The first scheme is based on the realized threshold bi-power variation correlation and the second one is based on the median realized correlation.

Corsi et al. (2010) showed that the threshold bi-power variation estimator substantially reduces the small-sample bias that the standard bi-power variation exhibits. The suggested volatility-jump detection scheme based on threshold bi-power variation (as used in Bekaert and Hoerova, 2014) is therefore applied to the detection of jumps in correlations. The realized correlation estimator used as a free-of-jumps realized correlation can be entitled as realized threshold bi-power variation correlation ($RTBPVC_{t,AB}$) and is equal to $RBRC_{t,AB}$ divided by the square root of the threshold bi-power variation of the two assets ($TBPV_{t,A}, TBPV_{t,B}$)[14], as follows:

$$RTBPVC_{t,AB}=\frac{RBRC_{t,AB}}{\sqrt{TBPV_{t,A},TBPV_{t,B}}} \tag{3}$$

The jump detection scheme based on $TBPV_t(ZCJ_t^{(RTBPVC)})$ as settled by Andersen et al. (2006) is also employed to detect jumps in correlations, as follows:

$$ZCJ_t^{(RTBPVC)}=\sqrt{N}\cdot\frac{\left(RBRC_t-RTBPVC_t\right)RC_t^{-1}}{\left(\left(\xi_1^{-4}+2\xi_1^{-2}-5\right)max\left\{1,TQ_tRTBPVC_t^{-2}\right\}\right)^{1/2}} \tag{4}$$

where TQ_t is the realized tri-power quarticity, $TQ_t = N\cdot\xi_{4/3}^{-3}\cdot\sum_{i=1}^{(N-2)}|R_{t,i}|^{4/3}|R_{t,i+1}|^{4/3}|R_{t,i+2}|^{4/3}$, and converges in probability to integrated quarticity. The $ZCJ_t^{(RTBPVC)}$ statistic follows the standard normal distribution. A jump is considered to be significant if the test statistic exceeds the appropriate critical value

[13] The jumps are realized as they are estimated without any assumptions.
[14] As defined above and as examined in Sevi (2014).

of the standard normal distribution, denoted by Φ_α, at the α level of significance. A 5% significance level is employed in this study.[15] The jump component ($CJ_t^{(RTBPVC)}$) can be found as:

$$CJ_t^{(RTBPVC)} = [RBRC_t - RTBPVC_t] \times I\left[ZCJ_t^{(RTBPVC)} > \Phi_a\right] \tag{5}$$

where $I[\cdot]$ is the indicator function of the $ZCJ_t^{(RTBPVC)}$ statistic in excess of a given critical value of the Gaussian distribution Φ_a.

The second jump detection scheme is based on the median realized correlation. Andersen et al. (2012) suggest the median realized variance ($MedRV_t$) as one of the best alternative jump-robust estimators of realized variance. This jump detection scheme can also be employed for detecting correlation jumps. The realized correlation estimator used as a free-of-jumps median realized correlation ($MedRC_{t,AB}$) is the simple realized covariance ($RBRC_{t,AB}$) divided by the square root of the product of the median realized variances of the two assets ($MedRV_{t,A}, MedRV_{t,B}$), as:

$$MedRC_{t,AB} = \frac{RBRC_{t,AB}}{\sqrt{MedRV_{t,A}, MedRV_{t,B}}} \tag{6}$$

According to Andersen et al. (2012), the test statistic becomes:

$$ZCJ_t^{(MedRC)} = \sqrt{N} \cdot \frac{(RBRC_t - MedRC_t)\, RBRC_t^{-1}}{\left(0.96 \cdot max\left\{1, MedRQ_t MedRC_t^{-2}\right\}\right)^{1/2}} \tag{7}$$

with $MedRQ_t$ being an estimate of the integrated quarticity based on $MedRC_t$ ($MedRQ_t = \frac{3\pi}{9\pi+72-52\sqrt{3}} \cdot \left(\frac{N}{(N-2)}\right) \cdot \sum_{i=2}^{(N-1)} med\left(|R_{t,i-1}|, |R_{t,i}|, |R_{t,i+1}|\right)^4$). When $ZCJ_t^{(MedRC)}$ is significant, the difference between $RBRC_t$ and $MedRC_t$ is too large and should be considered as a jump. The jump component now is:

$$CJ_t^{(MedRC)} = [RBRC_t - MedRC_t] \times I\left[ZCJ_t^{(MedRC)} > \Phi_a\right] \tag{8}$$

where $I[\cdot]$ is the indicator function of the $ZCJ_t^{(MedRC)}$ statistic in excess of a given critical value of the Gaussian distribution Φ_a, with a 5% significance level being employed in our study.

4.3 The impact of the Greek government-debt crisis events

Following Lahaye et al. (2011), we use Tobit models in order to determine which Greek government-debt crisis events explain correlations and correlation jumps, as follows:

$$C_{t,i}^* = \mu + \mu_{t,i} + \epsilon_{t,i} \tag{9}$$

[15] The intensity and magnitude of correlation jumps does not change significantly when a 1% significance level is employed.

where $\epsilon_{t,i}$ is $NID(0,1)$, and $C^*_{t,i} = RBRC_{t,AB}$ or $CJ^{(MedRV)}_{t,i} = CJ^*_{t,i}$ if $SC_{t,i} > \bar{SC}_{t,i}$ and $CJ^{(TBPV)}_{t,i} = CJ^*_{t,i}$ if $SC_{t,i} \leq \bar{SC}_{t,i}$. $CJ^{(MedRV)}_t$ is the significant jump series according to the correlation jump detection scheme based on $MedRV_t$ correlation estimator, and $CJ^{(TBPV)}_t$ is the significant jump series according to the correlation jump detection scheme based on the $TBPV_t$ correlation estimator, whereas

$$SC_{t,i} = \frac{|RBRC_{t,i}|}{\sqrt{\frac{1}{6}\sum_{i=1}^{7}\left(|RV_i| - |\bar{RV}_i|\right)^2}} \tag{10}$$

The criterion depends on the relative magnitude of each country's absolute correlation aggregately standardized on the respective absolute correlation series across all seven European countries.

5 Empirical results

This section discusses the impact of Greek government-debt crisis events on correlations and correlation jumps of 2-year, 5-year, and 10-year Greek government bonds, as well as on CDS and stock indices. The impact of the Greek government-debt crisis events on European financial markets is revealed via four dummy variables (D_1, D_2, D_3, and D_4) and four series of news surprises on generic government bonds (SUR_{2Y}, SUR_{5Y}, SUR_{10Y}, and SUR_{CDS}). The results of the effects of the Greek government-debt crisis events in the European generic government bond, CDS, and stock markets are presented in Tables 2 and 3. In each table, the impacts are divided into impacts on correlations and impacts on correlation jumps.

More specifically, Table 2 reports the impact of Greek government-debt crisis events on the correlations and correlation jumps of the considered European financial markets (2-year, 5-year, and 10-year bonds, stock, and CDS) via three dummy variables (D_1, D_2, and D_3) representing Greek government news from Greek, European, and international official sources, respectively, while the fourth dummy (D_4) corresponds to all news inclusively. The results reveal that most impacts are statistically significant at the 5% level. With regard to the effects in correlations, we notice that most of the impacts of the dummy variables on correlations are positive for European stock and CDS markets but negative for government bonds. Interestingly, among the three categories of sources of news (D_1, D_2, and D_3), news from Greek official sources (D_1) has the highest effects in the correlation series of European stock and CDS markets, suggesting that news from Greek official sources is more important than news from European or international official sources for correlations of these markets. This result is important as news from the official sources of a member state of the EU (i.e., Greece) affects significantly the co-movements (and coherence) of European financial markets, and therefore the role of the Greek official sources should not be underestimated at the European level. On the other hand, news from European sources (D_2) has the highest effects in absolute terms in the correlation series of European 5-year and 10-year bonds among the three categories of news, whereas the results for the 2-year bonds depend

on the country. When comparing the results by country, the highest effects in correlations across all categories of news are found for Germany, followed by France, for all financial markets except for the CDS market, for which the highest effects are observed for Ireland. It is worth noting that Apergis et al. (2016) also showed that news created significant spillover effects across European CDS markets during the European debt crisis.

Nevertheless, the impact of the dummy variables on correlation jumps of European markets are rather mixed, pointing to differences between northern European countries (i.e., Germany and France) and the more financially distressed European countries (i.e. Greece, Ireland, Italy, Portugal, and Spain). Specifically, we find that overall for the more financially distressed European countries, although most impacts are negative, news from Greek official sources (D_1) constitutes the category of news with the highest effects in government-bonds' correlation jumps, and news from European official sources (D_2) represents the category of news with the highest effects in stock markets' correlation jumps, whereas the sources of news with the highest effects in CDS markets' correlation jumps are European and international official sources (D_2 and D_3). On the other hand, the results for the northern countries reveal that most impacts are positive and that news from international official sources (D_3) have the highest effects in all financial markets except for the 10-year government bonds, for which news from European sources (D_2) has the highest effects in their correlation jumps. Furthermore, when comparing the results by country, the highest effects in correlation jumps across all categories of news are observed for Italy (for the 5-year government-bond and stock markets), Ireland (for the 2-year government-bond and CDS markets), and Spain (for the 10-year government-bonds).

Although the results seem to paint a complex picture of the impact of the Greek debt crisis on European financial markets, our results reveal that key economic events associated with the turbulence in the Greek economy significantly affect both correlation and correlation jump series. But more importantly, our findings show that the Greek events do not affect all European financial markets in the same way and/or that the transmission of turbulence may differ (i.e., through the realized correlations or through correlation jumps). Our findings further imply that to some extent, the Greek crisis events are increasing the level of contagion in European financial markets, yet after a point (i.e., when a significant jump occurs) we have a unilateral increase in the volatility of one market but not in the other one, indicating heterogeneity in the volatility responses to Greek news, which in turn cannot be translated into a respective increase in the covariance. This is evident in the results discussed above regarding the positive effects in correlations but negative effects in correlation jumps which were found for the stock and CDS markets in particular. This finding is consistent with the relevant literature which indicates different patterns of shock transmissions in the Euro area caused by the heterogeneity emerging from balance inequalities among the member states (see Fernández-Rodríguez et al., 2015; Garcia-de-Andoain and Kreme, 2017; Metiu, 2017; Gkillas et al., 2020).

Overall, the negative effects in correlations of European financial markets that are found in most cases, and in government bonds in particular, can be explained by the negative nature of government bond news.[16]

[16] All news in the sample (from each and all of the three sources of news, i.e. Greek, European, and international official sources) concern deterioration of the Greek economy, and in particular deterioration of Greek government bonds (2-year, 5-year, 10-year, CDS).

Bond market performance is generally viewed as an indicator of economic conditions, while it reflects investor expectation of future economic developments. News is thus negatively perceived by these markets as reflected in the impacts on correlations. In a similar vein, Beetsma et al. (2017) found that more news tends to lower the covariance of distressed countries' yields with German bond yields. Moreover, Caporale et al. (2016) found that markets are particularly responsive to negative news, with the reaction being larger in the more financially distressed countries. The effects in jumps in European correlation series, especially in the case of the more financially distressed countries, are also found to be negative, suggesting that negative news further affects the breaks (i.e., jumps) of correlations negatively. This result can be attributed again to the nature of events. Each and all sources of news together (Greek-D_1, European-D_2, international-D_3, and all together-D_4 official sources) for Greek government bonds have a similar effect in terms of breaks in correlations, in particular for the more financially distressed countries. This result indicates that news from official sources has a negative (adverse) effect in an adverse (negative)-in-nature discontinuity (i.e., jump) of correlations. This in turn reveals that news from all Greek, European, and international official sources adversely affect any aspect of financial markets, especially of the periphery EMU countries. In addition, the finding that across all categories of news, the highest effects in correlations are found for Germany and France, and in correlation jumps for Ireland, Italy, and Spain shows that the Greek news do not affect all the European countries considered in our study in the same way. This result indicates the importance of Greek news revealing both a strong systemic relation of Germany and France (as core EMU economies) and a strong un-systemic relation of Ireland, Italy, and Spain (as periphery EMU economies) with European financial markets (see, e.g., Acharya et al., 2012; Albrizio et al., 2020). Such evidence is consistent with the prevalent point of view that shocks from peripheral European countries are sources of shocks to both European and non-European regions (see e.g. Antonakakis and Vergos, 2013; Fernández-Rodríguez et al., 2015). The results enable us to understand the importance of the Greek sovereign debt crisis (via related news) to European financial markets and most importantly to the European sovereign debt crisis. As argued by Fernández-Rodríguez et al. (2015) and Aizenman et al. (2013), over the first ten years of the EMU, peripheral countries imported credibility from the core, while as the crisis started, investors turned their attention to fiscal imbalances and the domestic macroeconomic characteristics of each country. Yet, the potential Greek withdrawal from the Eurozone (Grexit) along with Grexit related news ignited widespread fears among investors of the political stability and solidity of the Euro area.

On the other hand, the effects of news surprises on 2-year, 5-year, and 10-year Greek government bonds, and CDS (SUR_{2Y}, SUR_{5Y}, SUR_{10Y}, and SUR_{CDS}, respectively) in the correlations and correlation jumps of the European financial markets (generic government bonds, stock, and CDS) are illustrated in Table 3. Once again, most impacts on the correlations and correlation jumps are statistically significant at the 5% level. Moreover, as could have been expected, most of the impacts of news surprises on correlations of European financial markets are negative. However, while the impacts of news surprises on correlation jumps of the Greek financial markets are all found positive, the effects of news surprises in correlation jumps of other European markets are rather mixed. In particular, news surprises on 2-year, 5-year, and 10-year bonds, and CDS are

found to have a negative impact on correlations and a mostly positive impact on correlation jumps, especially for the more financially distressed countries. News surprises are thus perceived by the markets negatively for correlations and mostly positively for correlation jumps, as expected.

We further find that the highest impacts in absolute terms on the correlations of European financial markets are observed for news surprises on the 2-year Greek government bonds (SUR_{2Y}), irrespective of the country under consideration. News about the shortest Greek government bonds is therefore more important than news related to other lengthier term durations. This result is in accordance with what is expected in bond markets, where the longer the term to maturity is, the higher the interest rate on the bond will be and the less volatile its price will be on the secondary bond market. This is the reason why short-term bonds are expected to be affected to a greater extent by news. On the other hand, the lowest negative effects come from news surprises on Greek CDS.

Similarly, news surprises on 2-year Greek government bonds (SUR_{2Y}) also have the highest effects in correlation jumps overall among all bond-related news surprises. Again, news about the shortest Greek government bonds is thus more important than news related to other lengthier term durations, as consistent with the economic theory about bonds, similar to the results found for correlations. Further, news surprises on Greek CDS exhibit the lowest effect, accordingly. When comparing the results by country, the highest effects in correlation jumps are found for Greece across all financial markets except for the stock market, for which the highest effect of news surprises is found for France. What is more, the positive and statistically significant effects found suggest that news surprises related to Greek government bonds result in breaks (i.e., jumps) in correlations, and thus in co-movements, with other European markets, especially in the financially distressed countries.

Overall, a closer look at the estimated effects shows several discrepancies in the results between the northern European countries and the more financially distressed countries, in particular in the signs of the effects in their correlation jumps, revealing that breaks in the co-movements of European financial markets drive the differences between the core and periphery EMU countries. However, we find significant effects in realized correlations and correlation jumps not only of periphery EMU countries but also of core EMU countries. The significant effects in realized correlations and correlation jumps of Germany in particular reinforce the importance of German co-movements with European financial markets in terms of news from official sources (see also Garcia-de-Andoain and Kremer, 2017; Ehrmann and Fratzscher, 2017). The realized correlations and correlation jumps of France with other European stock markets are also heavily affected by news surprises on Greek government bonds. This may be explained by the relation of the Greek government finances with Euronext.

What is more, the results show that news from Greek official sources have higher effects than the respective Greek government bonds' news surprises. It is therefore not the nature of Greek government bonds that mostly affect European financial co-movements (i.e., whether the bond is 2-year, 5-year, 10-year, or CDS) but the group of official sources of communication (Greek, European, or international) that mostly affects correlations

and particularly correlation jumps. The results of the different categories of official sources of news reveal significant effects in realized correlations of Germany, which means that all official sources of news related to the Greek sovereign debt crisis strongly affect the relation of Germany with both the core and periphery European financial markets. Our findings about news surprises strengthen the aforementioned result, since Germany is also affected by news surprises similar to the other considered European countries' financial markets. Garcia-de-Andoain and Kremer (2017) noted that Germany stands as one of the major sovereign stress transmitters to most countries of the Euro area, yet more interestingly, in our analysis we show that its relationships with other European markets are heavily affected by Greek news. Such evidence sheds more light on how the channel of transmission of stress is formed, as the European sovereign crisis progressed from Greece and passed to the reactions of core EMU countries. The results of both official sources and news surprises therefore reveal a strong relationship between Germany and Greece. On the other hand, Greece is the country that is impacted the most by news surprises in its correlation jumps, as expected.

In terms of policy implications, our results suggest that all Greek government bond news strongly affect the coherence and unity of the EMU. The fact that news severely also affects the breaks (i.e., discontinuity) of the European financial co-movements further highlights that investors in European financial markets react more vigorously to crisis events, taking the heterogeneity that exists among the member states into account. Our results further reveal that the European financial markets have started to differ (by having different distributional properties of realized correlations as well as different reactions to crisis events), with the European financial markets having been indeed differentiated between core and periphery countries, setting the EMU unity and EMU financial markets' efficiency in danger. Yet, our results confirm the importance of the relationship between Greece and core EMU countries, such as Germany.

Finally, Table 4 reports the summarized results of the impacts of Greek government-debt crisis events affecting the Greek economy on the correlations and jumps of correlations of the European financial markets (generic government bonds, stock, and CDS) via both dummy variables and news surprises. The sign of the impacts and the category of events with the highest impacts are also reported.

6 Concluding remarks

The Greek government-debt crisis following the global financial crisis of 2008 led to the use of a financial support rescue mechanism by the EMU and the IMF. Political uncertainty in conjunction with fiscal problems led the Greek economy to an unprecedented crisis culminating the impositions of capital controls in outflow funds from the domestic authorities as well as a short-term banking holiday. This paper examined the impact of Greek government-debt crisis events, with a focus on instability events, on inter-relations of European financial markets. Specifically, the impact of three categories of events on realized correlations and correlation jumps of government bonds, CDS, and stock indices of seven European countries was examined via the respective dummy variables and news surprises on 2-year, 5-year, and 10-year government bonds, and CDS, within a

Tobit regression framework.

When comparing the results by market, the direction of the impacts of news on correlations was found negative for all the European financial markets considered in this study except for the stock and CDS markets. Most of the impacts of news surprises on correlations of European financial markets were also found negative. Furthermore, for the stock and CDS markets, the highest impacts of news on correlation series resulted from news originating from Greek official sources, whereas for the 5-year and 10-year bonds the highest effects in correlations resulted from news from European sources. In terms of impacts on correlation jumps, it was shown that in the more financially distressed European countries, the highest effects of news in correlation jumps of bond and stock markets resulted from news from Greek and European official sources, respectively, whereas the highest effects in correlation jumps of CDS markets resulted from news from European and international official sources. On the other hand, for the northern countries, the highest effects in correlation jumps in all financial markets except for the 10-year government bond resulted from news from international sources. In addition, news surprises on 2-year Greek government bonds and Greek CDS were found to have the highest and lowest, respectively, impacts on both correlations and correlation jumps.

When comparing the results by country, the highest effects of news in correlations across all categories of news were found for Germany, followed by France, for all financial markets except for the CDS. On the other hand, the highest effects in correlation jumps across all categories of news were found for the more financially distressed European countries. Finally, the direction of most of the impacts of news on correlation jumps was found negative for the more financially distressed European countries but positive for the northern countries, pointing to differences between core and periphery EMU countries.

Our study extends the findings of Kosmidou et al. (2015) who provided evidence of a positive effect of news releases in risk and a negative impact of news releases on returns, as it goes one step further by examining the impact of Greek news in the interconnectedness of European financial markets. Our results also support the findings of Samarakoon (2017) who found evidence of negative contagion from crisis countries, which were used as proxies for the Eurozone debt crisis, to other stock markets. Nevertheless, our results are not in accordance with the study of Samitas and Tsakalos (2013) which did not find evidence of contagion effects during the Greek government-debt crisis.

Our findings have various important implications for the market participants and policymakers (i.e., troika and the Greek Government) but also for financial sector regulators, as the above results improve our understanding of the link between news releases and inter-relations of European financial markets as well as of the contagion during the Greek sovereign debt crisis. For instance, the negative impacts on correlations and correlation jumps that have been found suggest that the Greek government-debt crisis events reduced the homogeneity among member states in the Eurozone. Such events introduced innovations in the markets and under conditions of uncertainty provide additional understanding of the generated mechanism of the heterogeneity among member states of the Eurozone which in turn may also impact the inter-relations between the corresponding financial markets in a different way. This can be useful for policymakers in order to better

understand the inequalities between the periphery and core EMU countries. But more importantly, although there is evidence that the events of the Greek debt crisis do not affect all European financial markets in the same way, our findings reveal that the significance of Greek crisis events in the Eurozone stands as a clear signal of the so-called "wake-up call" view, as first noted by Mink and de Haan (2013).

7 Data availability statement

Data available on request due to privacy/ethical restrictions.

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Tables

Table 1. Data

Panel A. Events			Panel B. Generic Government Bonds		Panel C. Stock indices		Panel D. Credit Default Swaps (CDSs)	
Symbol	Days	Months	Symbol	Description	Symbol	Description	Symbol	Description
D_1	59	26	GR_{10Y}	Greece 10-Year	GR_{Stock}	Greece ASE index	GR_{CDS}	GREECE CDS USD SR 5Y CBIN Corp
D_2	34	23	GR_{5Y}	Greece 5-Year	ESP_{Stock}	Spain IBEX index	ESP_{CDS}	SPAIN CDS USD SR 5Y cbin Corp
D_3	39	14	GR_{2Y}	Greece 2-Year	P_{Stock}	Portugal BVLX index	P_{CDS}	PORTUG CDS USD SR 5Y cbin Corp
D_4	132	63	ESP_{10Y}	Spain 10-Year	IRL_{Stock}	Ireland ISEQ index	IRL_{CDS}	IRELND CDS USD SR 5Y cbin Corp
			ESP_{5Y}	Spain 5-Year	I_{Stock}	Italy FTSEMIB index	I_{CDS}	ITALY CDS USD SR 5Y cbin Corp
			ESP_{2Y}	Spain 2-Year	DE_{Stock}	Germany DAX index	DE_{CDS}	GERMAN CDS USD SR 5Y cbin Corp
			P_{10Y}	Portugal 10-Year	F_{Stock}	France CAC index	F_{CDS}	FRANCE CDS USD SR 5Y cbin Corp
			P_{5Y}	Portugal 5-Year				
			P_{2Y}	Portugal 2-Year				
			IRL_{10Y}	Ireland 10-Year				
			IRL_{5Y}	Ireland 5-Year				
			IRL_{2Y}	Ireland 2-Year				
			I_{10Y}	Italy 10-Year				
			I_{5Y}	Italy 5-Year				
			I_{2Y}	Italy 2-Year				
			DE_{10Y}	Germany 10-Year				
			DE_{5Y}	Germany 5-Year				
			DE_{2Y}	Germany 2-Year				
			F_{10Y}	France 10-Year				
			F_{5Y}	France 5-Year				
			F_{2Y}	France 2-Year				

Notes. Table 1 reports the data employed in the paper. Panel A depicts the Greek government-debt crisis events examined in the paper. Events that directly affected the Greek economy are split into three categories (D_1, D_2, and D_3) and all together (D_4). The three categories concern events coming from: (i) Greece, (ii) Eurozone, and (iii) international entities, respectively. Panels B, C and D depict the symbols and description of the data series of Greece, Spain, Portugal, Ireland, Italy, Germany and France for the generic government bonds, stock indices[17] and CDSs, accordingly.

[17] Additionally, the Euro Area SX5E index is included, concerning the Euro Area.

Table 2. Impact of Greek government-debt crisis events on correlations and correlation jumps - Dummy variables

		Correlations					Correlation Jumps				
		10-Year	5-Year	2-Year	Stock	CDS	10-Year	5-Year	2-Year	Stock	CDS
GR	% neg. coeff.	1	1	85.70%	0	42.90%	57.14%	57.14%	71.43%	28.57%	1
	D_1	-0.0175*	-0.0374*	-0.0124*	0.0998*	0.0972*	-0.0072*	-0.0288*	-0.0689*	0.0343*	-0.0609*
	D_2	-0.0815*	-0.0448*	-0.0315*	0.0238*	-0.0582*	0.0066*	0.0390*	0.0428*	-0.0403*	-0.0167*
	D_3	-0.0548*	-0.0844*	-0.0570*	0.0578*	0.0372*	-0.0188	-0.0154*	-0.0378*	0.0292*	-0.0699*
	D_4	-0.0772*	-0.1113*	-0.0740*	0.0604*	0.0317*	-0.0092*	0.0015*	-0.0362*	0.0156*	-0.0644*
ESP	% neg. coeff.	1	71.40%	42.90%	28.60%	14.30%	1	57.14%	42.86%	57.14%	42.86%
	D_1	-0.0280*	0.0019	-0.0242*	0.0621*	0.1117*	-0.0747*	-0.0565*	-0.0567*	0.0146*	0.0107*
	D_2	-0.0919*	-0.0393*	0.0059*	-0.0060*	0.0276*	-0.0210*	0.0207*	0.0447*	-0.0720*	0.0336*
	D_3	-0.0490*	-0.0159*	0.0018	0.0077*	0.0475*	-0.0410*	-0.0136*	0.0135*	-0.0229*	-0.0116*
	D_4	-0.1133*	-0.0571*	-0.0317*	0.0591*	0.0789*	-0.0759*	-0.0281*	-0.0041	0.0035*	-0.0272*
P	% neg. coeff.	1	1	1	28.60%	0	85.71%	85.71%	57.14%	85.71%	71.43%
	D_1	-0.0467*	-0.0602*	-0.0289*	0.0749*	0.0621*	-0.0625*	-0.0567*	-0.0766*	-0.0130*	-0.0559*
	D_2	-0.1892*	-0.1263*	-0.0745*	0.0245*	0.0582*	-0.0430*	-0.0022	0.0098	-0.0733*	0.0563*
	D_3	-0.0567*	-0.0690*	-0.0649*	-0.0056	0.0697*	-0.0220*	-0.0185*	-0.0019	-0.0533*	-0.0255*
	D_4	-0.1689*	-0.1609*	-0.1052*	0.0738*	0.0520*	-0.0707*	-0.0526*	-0.0425*	-0.0197*	-0.0526*
IRL	% neg. coeff.	1	1	28.60%	0	0	1	42.86%	71.43%	28.57%	42.86%
	D_1	-0.0391*	-0.0616*	-0.0299*	0.1164*	0.0736*	-0.0400*	-0.0087*	-0.0953*	0.0068*	-0.0386*
	D_2	-0.1629*	-0.0864*	0.0185*	0.0345*	0.1255*	-0.0118*	0.0264*	0.0874*	-0.0095*	0.0885*
	D_3	-0.0838	-0.0572*	0.0174*	0.0719*	0.0840*	-0.0440*	0.0092*	-0.0410*	0.0054	0.0121*
	D_4	-0.1376*	-0.0968*	9.55E-04	0.1375*	0.1160*	-0.0462*	-0.0021*	-0.0376*	0.0405*	-0.0201*
I	% neg. coeff.	1	1	1	57.10%	42.86%	71.43%	57.14%	71.43%	71.43%	57.14%
	D_1	-0.0498*	-0.0885*	-0.0725*	0.0916*	0.0957*	-0.0307*	-0.0645*	-0.0843*	0.0373*	-0.0145*
	D_2	-0.1844*	-0.1381*	-0.0744*	-0.0377*	-0.0273*	-0.0377*	0.0108*	0.0268*	-0.1060*	0.0110*
	D_3	-0.0812*	-0.0808*	-0.0831*	-0.0314*	0.0265*	0.0058	-0.0136*	-0.0384*	-0.0818*	-0.0531*
	D_4	-0.1639*	-0.1868*	-0.1217*	0.0709*	0.0319*	-0.0365*	-0.0528*	-0.0450*	-0.0241*	-0.0547*
DE	% neg. coeff.	1	1	1	28.57%	0	28.57%	42.86%	28.57%	28.57%	71.43%
	D_1	-0.1048*	-0.1261*	-0.1411*	0.1329*	0.0959*	-0.0058*	-0.0225*	-0.0127*	0.0390*	-0.0339*
	D_2	-0.1349*	-0.1569*	-0.1187*	0.0939*	0.0334*	0.0409*	0.0139*	0.0075	0.0044	0.0129*
	D_3	-0.1055	-0.1093*	-0.0840*	-0.0243	0.0950*	0.0255*	0.0226*	0.0438*	-0.0459*	-0.0546*
	D_4	-0.2323*	-0.2276*	-0.1802*	0.1399*	0.1001*	0.0085*	-0.0015	0.0128*	0.0624*	-0.0616*
F	% neg. coeff.	1	1	85.70%	28.60%	28.57%	0	71.43%	42.86%	57.14%	42.86%
	D_1	-0.0577*	-0.1126*	-0.0954*	0.1226*	0.1135*	0.0063	-0.0165*	0.0095	0.0269*	0.0090
	D_2	-0.1308*	-0.1562*	-0.1104*	0.0039	-0.0441*	0.0221*	-9.06e-4*	-0.0089	-0.0740*	0.0098
	D_3	-0.1008*	-0.1008*	-0.0319	-0.0321*	0.0707*	0.0131*	0.0225*	0.0551*	-0.0799*	-0.0357*
	D_4	-0.1645*	-0.1938*	-0.1267*	0.1083*	0.0462*	0.0167*	-0.0062	0.0119*	0.0108*	-0.0644*

Notes. Table 2 reports the impact of Greek government-debt crisis events on the correlations and jumps

of correlations of the European financial markets (generic government bonds, stock and CDS) via dummy variables. % neg. coeff. is the percentage (%) of negative coefficients across all surprises variables. The D_1, D_2, D_3 and D_4 refer to the dummy variables as explained in Section 3. Each reported value concerns the average value across the impacts of the correlations (or the jumps of correlations) among the respective reported financial asset and all the remaining. * indicates significance of coefficient estimate at a 5% level of significance.[18]

[18] Heteroscedasticity and autocorrelation consistent (Newey-West) standard errors are employed in the calculation of the corresponding significance level and are available upon request.

Table 3. Impact of Greek government-debt crisis events on correlations and correlation jumps - Surprises

		Correlations					Correlation Jumps				
		10-Year	5-Year	2-Year	Stock	CDS	10-Year	5-Year	2-Year	Stock	CDS
GR	% neg. coeff.	1	1	1	1	1	0	0	0	0	0
	SUR_{2Y}	-0.0106*	-0.0085*	-0.0084*	-0.0024*	-0.0113*	0.0021*	0.0027*	0.0042*	0.0021*	0.0063*
	SUR_{5Y}	-0.0022*	-0.0021*	-0.0025*	-0.0018*	-0.0046*	3.63e-4*	0.0012*	0.0021*	4.16e-4*	0.0039*
	SUR_{10Y}	-4.52e-4*	-4.42e-4*	-5.60e-4*	-4.45e-4*	-0.0011*	8.47e-5*	2.80e-4*	4.88e-4*	8.08e-5*	9.28e-4*
	SUR_{CDS}	-5.83e-5*	-5.38e-5*	-5.93e-5*	-2.94e-5*	-1.00e-4*	8.67e-6*	2.14e-5*	4.38e-5*	8.65e-6*	8.27e-5*
ESP	% neg. coeff.	1	1	1	75.00%	1	25.00%	0	0	25.00%	0
	SUR_{2Y}	-0.0183*	-0.0136*	-0.0130*	6.59e-04	-8.44e-4*	7.34e-4*	0.0011*	0.0025*	-5.80e-04	0.0012*
	SUR_{5Y}	-0.0037*	-0.0032*	-0.0037*	-3.59e-4*	-0.0017*	4.95e-5*	1.84e-4*	8.36e-4*	9.33e-4*	-3.07e-4*
	SUR_{10Y}	-7.79e-4*	-6.63e-4*	-8.32e-4*	-7.57e-5*	-4.33e-4*	2.74e-4*	4.25e-5*	2.15e-4*	2.41e-4*	-7.31e-5*
	SUR_{CDS}	-1.00e-4*	-8.15e-05	-8.84e-05	-2.63e-6*	-1.94e-5*	-1.16e-06	2.43e-06	1.78e-5*	1.13e-5*	4.29e-6*
P	% neg. coeff.	1	1	1	50.00%	1	0	1	0	0	0
	SUR_{2Y}	-0.0168*	-0.0153*	-0.0103*	0.0013*	-0.0069*	4.16e-4*	-0.0015*	0.0012*	0.0014*	0.0013*
	SUR_{5Y}	-0.00215*	-0.0023*	-0.0010*	-1.15e-4*	-0.0025*	1.34e-4*	-3.03e-4*	0.0011	0.0019*	0.0011*
	SUR_{10Y}	-3.91e-4*	-4.36e-4*	-1.67e-4*	-1.13e-5*	-5.84e-4*	4.40e-5*	-5.85e-5*	2.59e-4*	4.64e-4*	2.68e-4*
	SUR_{CDS}	-6.95e-5*	-6.82e-5*	-3.75e-5*	3.15e-06	-3.68e-5*	2.37e-6*	-1.05e-5*	2.24e-5*	2.97e-5*	2.74e-5*
IRL	% neg. coeff.	1	1	1	75.00%	1	0	1	0	25.00%	50.00%
	SUR_{2Y}	-0.0184	-0.0109	-0.0127*	0.0032*	-0.0021*	0.0014*	-0.0018*	0.0029*	-1.05e-05	-5.82e-5*
	SUR_{5Y}	-0.0020*	-0.0012*	-0.0031*	-9.92e-4*	-0.0021*	4.86e-4*	-0.0013*	9.07e-4*	6.52e-4*	2.64e-6*
	SUR_{10Y}	-3.41e-4*	-2.05e-4*	-6.73e-4*	-2.43e-4*	-5.18e-4*	1.55e-4*	-2.81e-4*	2.02e-4*	1.53e-4*	-7.40e-07
	SUR_{CDS}	-7.08e-5*	-4.02e-5*	-7.75e-5*	-1.04e-5*	-2.49e-5*	6.12e-6*	-3.07e-5*	2.10e-5*	2.60e-6*	8.87e-6*
I	% neg. coeff.	1	1	1	0	1	0	1	0	0	0
	SUR_{2Y}	-0.0154*	-0.0164*	-0.0095*	0.0046	-8.68e-4*	0.0012*	-7.21e-4*	0.0017*	0.0022*	0.0021*
	SUR_{5Y}	-0.0018*	-0.0019*	-8.62e-04	6.01e-04	-0.0012*	4.00e-4*	-1.23e-4*	0.0012*	0.0024*	8.45e-4*
	SUR_{10Y}	-3.20e-4*	-3.48e-4*	-1.43e-4*	1.74e-04	-2.83e-4*	1.21e-4*	-2.51e-5*	2.90e-4*	6.04e-4*	2.17e-4*
	SUR_{CDS}	-6.33e-5*	-6.15e-05	-3.43e-5*	1.97e-5*	-1.51e-5*	6.55e-6*	-3.78e-6*	2.54e-5*	4.28e-5*	2.10e-5*
DE	% neg. coeff.	1	1	1	0	1	1	0	75.00%	0	25.00%
	SUR_{2Y}	-0.0198*	-0.0163*	-0.0139*	0.0037*	-0.0014*	-0.0015*	0.0010*	3.21e-4*	8.92e-5*	-0.0024*
	SUR_{5Y}	-0.0189*	-0.0012*	-8.91e-04	2.20e-4*	-0.0030*	-3.91e-4*	1.96e-4*	-2.33e-4*	0.0014*	9.72e-4*
	SUR_{10Y}	-4.09e-4*	-1.60e-4*	-1.28e-4*	3.44e-5*	-7.20e-04	-1.15e-4*	3.33e-5*	-7.64e-5*	3.66e-4*	2.57e-4*
	SUR_{CDS}	-7.13e-05	-5.03e-5*	-3.97e-5*	5.17e-6*	-4.92e-5*	-9.71e-6*	4.23e-6*	-4.28e-6*	1.81e-5*	1.75e-5*
F	% neg. coeff.	1	1	1	0	50.00%	1	1	75.00%	0	25.00%
	SUR_{2Y}	-0.0140*	-0.0131*	-0.0097*	0.0060*	0.0014	-3.28e-4*	-9.26e-4*	5.62e-04	0.0025*	-0.0025
	SUR_{5Y}	-0.0018*	-0.0011*	-0.0014*	6.69e-4*	-6.68e-4*	-5.38e-4*	-4.08e-4*	-5.40e-4*	0.0022*	4.39e-4*
	SUR_{10Y}	-3.11e-4*	-1.44e-4*	-2.95e-04	1.87e-04	-1.84e-4*	-1.12e-4*	-9.42e-5*	-1.46e-5*	5.68e-4*	1.32e-4*
	SUR_{CDS}	-5.93e-05	-4.44e-05	-4.22e-5*	1.97e-05	2.91e-6*	-1.37e-5*	-1.06e-5*	-9.96e-6*	3.55e-5*	7.93e-6*

Notes. Table 3 reports the impact of Greek government-debt crisis events on the correlations and jumps of

correlations of the European financial markets (generic government bonds, stock and CDS) via surprises. % neg. coeff. is the percentage (%) of negative coefficients across all surprises variables. The SUR_{10Y}, SUR_{5Y}, SUR_{2Y} and SUR_{CDS} refer to the coefficients of the equations. Each reported value concerns the average value across the impacts of the correlations (or the jumps of correlations) among the respective reported financial asset and all the remaining. * indicates significance of coefficient estimate at a 5% level of significance.[19]

[19]Heteroscedasticity and autocorrelation consistent (Newey-West) standard errors are employed in the calculation of the corresponding significance level and are available upon request.

Table 4. Summarized results

	Correlations				Correlation Jumps			
	Dummies		Surprises		Dummies		Surprises	
	Sign	News	Sign	News	-Sign	News	Sign	News
GR	-	*Greek_fin_sources*	-	2Y	-	*Greek_fin_sources*	+	2Y
ESP	+	*Greek_fin_sources*	-	2Y	-	*Greek_fin_sources*	+	2Y
P	-	*European_fin_sources*	-	2Y	-	*Greek_fin_sources*	+	2Y
IRL	+	*European_fin_sources*	-	2Y	+	*European_fin_sources*	+	2Y?
I	-	*Greek_fin_sources*	-	2Y	-	*Greek_fin_sources*	+	2?
DE	-	*Greek_fin_sources*	-	2Y	+	*International_fin_sources*	+	2Y
F	-	*European_fin_sources*	-	2Y	+	*International_fin_sources*	-	2Y
E?U	-	*Greek_fin_sources*	-	2Y	-	*Greek_fin_sources*	+	2Y

Notes. Table 4 reports the summarized results of the impact of Greek government-debt crisis events affecting the Greek economy on the correlations and the jumps of correlations of the European financial markets (generic government bonds, stock and CDS) via dummy variables and surprises. The sign of the impact and the category of news releases with the highest impact are reported.[20]

[20]Heteroscedasticity and autocorrelation consistent (Newey-West) standard errors are employed in the calculation of the corresponding significance level and are available upon request.