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Volatility dynamics between green and sovereign bonds in Europe

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Abstract

The paper is a study on the dynamical conditional correlations between the European markets of green and sovereign bonds before and during the pandemic. To this purpose, we apply the Dynamic Conditional Correlation Generalized AutoRegressive Conditional Heteroskedasticity (DCC-GARCH) model to the Bloomberg MSCI Euro Green Bond Index and to S&P Eurozone Sovereign Bond Index. After calculating the univariate GARCH for each series, the model allows us to observe the dynamic interrelations over the short and long run for both periods of analysis. Our main results demonstrate that if the long term parameter is significant each time, in the short run the two indices are dynamically conditionally correlated only during the pandemic. We deem this issue interesting in terms of portfolio construction as it testifies that the two market segments can be allocated for diversification purposes in the short run during “normal” times, while this property vanishes in periods of crisis. All in all green bonds seem to present analogous behaviors with conventional bonds so they cannot be regarded as a different asset class, but they are fundamentally substitutes or supplements of more traditional fixed income securities. Notwithstanding they allow investors to integrate climate risk in their portfolios showing a risk-return profile similar to that of Treasury bonds. The added value of our research is given by the focus on the volatility connections between the green and sovereign segments of the European fixed income: to the best of our knowledge there is lacking research on this topic.

Keywords – Green bonds; Sovereign bonds; Volatility

Paper type – Academic Research Paper

Sommario

L'articolo presenta uno studio sulle correlazioni dinamiche condizionali tra i mercati europei delle obbligazioni verdi e sovrane prima e durante la pandemia. A tal fine, si applica il modello Dynamic Conditional Correlation Generalized AutoRegressive Conditional Heteroskedasticity (DCC-GARCH) agli indici *Bloomberg MSCI Euro Green Bond* e *S&P Eurozone Sovereign Bond*. Dopo aver calcolato il GARCH univariato per ogni serie, il modello consente di osservare le interrelazioni dinamiche nel breve e nel lungo termine per entrambi i periodi di analisi. I risultati principali dimostrano che se il parametro di lungo termine è significativo ogni volta, nel breve periodo i due indici sono dinamicamente correlati in modo condizionato solo durante la pandemia. Si ritiene tale aspetto interessante in termini di costruzione di portafoglio, in quanto testimonia che i due segmenti di mercato possono essere allocati con lo scopo di diversificare gli investimenti nel breve periodo in tempi "normali", mentre questa proprietà svanisce in periodi di crisi. Nel complesso, i green bonds sembrano presentare comportamenti analoghi a quelli delle obbligazioni convenzionali, per cui non possono essere considerati una classe differente di attivi, ma sono fondamentalmente sostituiti dei titoli a reddito fisso più tradizionali. Tuttavia, consentono agli investitori di integrare il rischio climatico nei propri portafogli, mostrando un profilo di rischio-rendimento simile a quello dei titoli del Tesoro. Il valore aggiunto della ricerca è dato dal focus sulle connessioni di volatilità tra i segmenti green e sovrano del reddito fisso europeo: tale aspetto risulta essere innovativo in letteratura.

Parole chiave – Obbligazioni green; Obbligazioni sovrane; Volatilità

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1 Introduction

Green bonds constitute a specific segment of the fixed income, able to implement the intertemporal burden sharing of climate mitigation across generations (Flaherty et al., 2017; Orlov et al., 2017; Andersen et al., 2016; Sachs, 2014) and to finance the development of the low-carbon transition (Monasterolo & Raberto, 2018). Furthermore, it's demonstrated that the non-pecuniary motivates (especially pro-environmental preferences) grant a significant, but low, premium that highlights the opportunity for issuers to expand their bondholders (Zerbib, 2019).

Consistently, the attractiveness of these bonds is testified by the exponential growth that the market has recorded, even during the pandemic period. More specifically, though the sustainable bond market has been characterized by a further split in its themes, in terms of social, sustainable and pandemic bonds, the green segment has shown an increasing demand and better performances compared to plain vanilla debt instruments. In particular, over the 2020 the market has had a discontinuous trend: if in the first quarter its volume has dropped lower than a half of 2019 (Climate Bonds Initiative, 2020a), in the third quarter of 2020 green bonds have reached the highest volume of issuance for a third quarter, i.e., USD 69.4 bn (Climate Bonds Initiative, 2020b). As concerns 2021, at the end of the third quarter, the total issuance has reached USD 354.2 bn and it has shown a growth of 15.8% compared with Q3 2020 (Climate Bond Initiative, 2021a). In particular, the European market is the most developed in the world, being the source of numerous dedicated investment mandates, and the most advanced policy measures. Europe has been the most prolific region, with cumulative issuance reaching USD 758 bn by year end. Half of the 2021 green bond volumes originated in Europe and contributed USD 265 bn (50%) to the total. The most aggressive Year Over Year (YOY) growth in the region came from financial corporate (136%) and sovereign (103%) issuer types (Climate Bond Initiative, 2021b). Where practicable, issuers prefer to issue in EUR to obtain maximum investor diversification. In more detail, over the post-Covid inflationary environment, investors have put caution on the possibility that their returns could be eroded; notwithstanding, in the first semester of 2021 rates have remained low, thanks to the ongoing support of central banks and of other pandemic measures, contributing to bond price rising. Specifically, analyzing green bonds yields, researchers have observed a premium, called the “greenium”, that investors are willing to pay in order to make a sustainable investment (e.g., Hyun et al., 2020; Zerbib, 2019): in this sense the cost of debt should be lower than the conventional one. In particular, this phenomenon is typical of the primary market: the price of new issuance is higher than the outstanding debt. However, the market has shown larger spread compression than the plain vanilla's one: in the first half of 2021 it has tightened 24.4 bps (29.9 bps) for the EUR (USD) segment, compared to the 19.6 (24.8) bps of the plain vanilla bonds (Climate Bond Initiative, 2021b). This issue is explainable by the oversubscriptions of green bonds compared with the ongoing lack of supply. Looking more deeply to

the comparison between green and conventional bonds, Febi et al. (2019) observe the impact of liquidity risk on the yields and, despite the greater demand over the supply, they find that green bonds are more liquid than conventional ones over the period 2014-2016. They moreover confirm a positive correlation between liquidity risk and green bonds yields, but evidence that this effect gets negligible over time. Nanayakkara and Colombage (2019) investigate the price difference of green and conventional bonds, in a global study for the period 2016-2017. In particular they adopt the Option-Adjusted Spread (OAS) and control for the influence of bond specific, macroeconomic and global factors. They find that green bonds are traded at a premium of at least 63 bps, showing the investors' interest for these instruments as a source of portfolio diversification and important implications for stakeholders, in order to support the market growth. Also Ortolano and Nissi (2022) focus their research on the OAS of green bonds in order to observe the volatility of the credit risk component of the bonds both during and before the pandemic. Gianfrate and Peri (2019) analyze the convenience to issue bonds labeled as "green", versus conventional ones. Through a propensity score matching approach, made on European bonds over the period 2013-2017, they assess that there's a significant convenience to issue green bonds, expressed by lower interests paid annually to investors of 18 basis points. They also show that this advantage is achieved both by corporate and non-corporate entities and overcomes the extra costs, needed to obtain the "green" certification. Broadstock and Cheng (2019), studying the determinants of the time-varying correlation between the green and black bond markets over the period 28 November 2008-31 July 2018, find that the correlation changes over time and is sensitive to financial market volatility, economic policy uncertainty, daily economic activity and oil prices. Reboredo (2018) finds analogies with corporate and treasury bond markets. Hachenberg and Schiereck (2018) observe the risk-return profile, matching the daily i-spreads of green-labeled and similar non-green-labeled bonds in order to look at their pricing differentials. They find that rating classes AA-BBB of green bonds, trade marginally tighter for the respective period compared to non-green bonds of the same issuers. Furthermore, financial and corporate green bonds trade tighter than their comparable non-green bonds. The authors also observe that industry and ESG rating have a significant influence on the difference, contrary to issue size, maturity and currency. Finally, Ortolano and Angelini (2021), focusing the analysis on the green bonds listed in Borsa Italiana, find that market and macroeconomic variables affecting their capital gain change over time and in some cases present analogies with conventional bonds.

With reference to the overall fixed income market, credit risk has raised up during the pandemic period and has shown up and down correlations with the epidemic trend; however, the levels reached are definitely lower than those recorded during the Financial Crisis (Byström, 2021).

In this context, we focus our attention to the European sovereign bond market. Specifically, the total outstanding for the Euro area in February 2022 is equal to 9,984.8 billion euros (European Central Bank, 2022a). In particular, looking to the period 2016-2021 the debt expressed as a percentage of GDP is equal to 90 at the end of 2016, shows a slight decrease in the following three years, then reaches 97 at the end of 2020. In the third quarter of 2021, the euro debt is 97.7% of the GDP (European Central Bank, 2022b).

In order to understand the government bond market's behavior, Richter (2022) documents commonality in the liquidity of sovereign bonds, namely the occurrence of negative cross-market correlations of liquidity across several markets and time periods. More specifically he shows that local market-level liquidity changes exert a substantial influence on the liquidity of single bonds, while there is only little evidence that changes in global liquidity affect the liquidity of individual sovereign bond markets. Zaremba et al. (2021) demonstrate that during the pandemic, government interventions substantially reduced local sovereign bond volatility mainly through economic support policies. Karkowska and Urjasz (2021) study the volatility spillovers between selected post-communist countries from Central and Eastern Europe (CEE) and major global and European sovereign bond markets, over the period 2008-2020. They find that CEE countries are more interlinked with each other than with global markets, suggesting to look separately at advanced and developing bond markets in European countries, under a portfolio management perspective. Paule-Vianez et al. (2021), looking to the sovereign bonds yields during the pandemic for the G7 countries, observe that the fear for Covid impacts positively the ten-year bond yield, consistently with an increase of the country risk perception. Cevik and Jalles (2020) find that the vulnerability and resilience to climate change have a significant impact on the cost government borrowing; in particular, countries that are more resilient to climate change have lower bond yields and spreads relative to countries with greater vulnerability to risks associated with climate change.

The paper is a study on the dynamical conditional correlations between the European markets of green and sovereign bonds before and during the pandemic. To this purpose, we apply the DCC-GARCH model to the Bloomberg MSCI Euro Green Bond Index (hereinafter GREEN) and to S&P Eurozone Sovereign Bond Index (hereinafter SOV). After calculating the univariate GARCH for each series, the model allows us to observe the dynamic interrelations over the short and long run for both periods of analysis. Our main results demonstrate that if the long term parameter is significant each time, in the short run the two indices are dynamically conditionally correlated only during the pandemic. We deem this issue interesting in terms of portfolio construction as it testifies that the two market segments can be allocated for diversification purposes in the short run during “normal” times, while this property vanishes in periods of crisis.

The added value of our research is given by the focus on the volatility connections between the green and sovereign segments of the European fixed income: to the best of our knowledge there is lacking research on this topic.

2 Methodology and data

2.1 Methodology: the DCC-GARCH

The Dynamic Conditional Correlation GARCH model (DCC-GARCH) (Engle, 2002) is illustrated below.

The DCC-GARCH calculation is made by two steps.

The first step deals with the conditional heteroskedasticity. It consists in estimating, for each one of the n series of returns $r_{i,t}$, its conditional volatility $\sigma_{i,t}$ using a GARCH model. Let D_t be a diagonal matrix with these conditional volatilities, i.e. $D_t^{ii} = \sigma_{i,t}^2$ and, if $i \neq j$, $D_t^{ij} = 0$. Then the standardized residuals are:

$$v_t := D_t^{-1}(r_t - \mu)$$

$r_t = n \times 1$ vector of returns

$\mu = n \times 1$ vector of expected returns

The aforementioned standardized residuals have unit conditional volatility.

Now we define the Constant Conditional Correlation (CCC) (Bollerslev, 1990) through the following matrix:

$$R := \frac{1}{T} \sum_{t=1}^T v_t v_t'$$

The second step is the Dynamic Conditional Correlation (DCC) itself, i.e. the generalizing CCC model (Bollerslev, 1990) that captures the dynamics in the correlation:

$$Q_t = R + \lambda_1 (v_{t-1} v_{t-1}' - R) + \lambda_2 (Q_{t-1} - R)$$

So Q_t^{ij} is the correlation between $r_{i,t}$ and $r_{j,t}$

2.2 Data

The data adopted are made by the daily performances of the Bloomberg MSCI Euro Green Bond Index and S&P Eurozone Sovereign Bond Index, observed during two sub periods:

- 20th October 2016-20th February 2020;
- 21th February 2020-8th November 2021.

The pandemic period starts from the 21th February, when the Covid-19 officially started to spread in Italy.

Sources of data are Bloomberg and Standard & Poor's.

3 Results and discussion

We start the discussion of our main results, observing Table 1, where are reported the descriptive statistics, the normality and the Unit-root test for both periods.

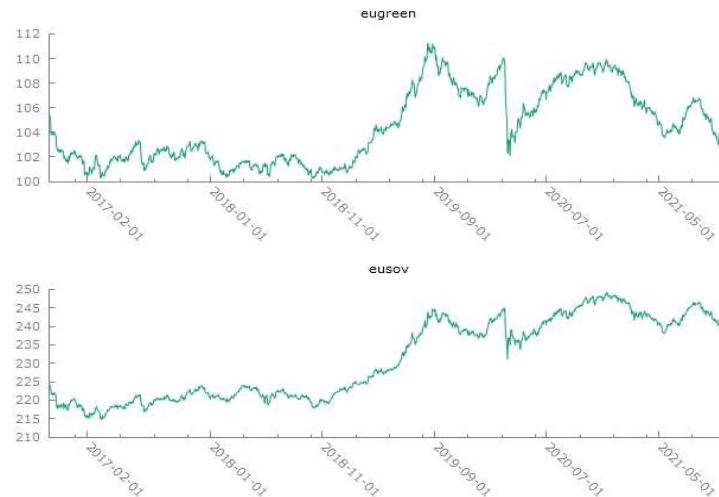
Table 1 - Descriptive statistics, Normality and Unit-root test

Non Pandemic period								
Variable	Mean	Min	Max	St. Dev.	Skewness	Kurtosis	JB test	ADF
GREEN	103.30	100.25	111.29	2.7761	1.1961	0.18895	207.051***	-0.00862683
SOV	225.09	214.87	244.60	8.0462	1.1175	-0.16737	180.627***	-2.16544
Obs. 863								
Pandemic period								
Variable	Mean	Min	Max	St. Dev.	Skewness	Kurtosis	JB test	ADF
GREEN	106.60	102.04	110.04	2.0522	-0.065426	-1.2390	116.225***	-0.0176958
SOV	242.81	230.98	249.03	3.4919	-0.41728	-0.29208	14.4958***	-2.15523
Obs. 445								

*** indicates statistical significance at 1% level

Source: our elaboration

We note that among the two periods of observation the mean value doesn't change considerably for each index. As also displayed by Figure 1, SOV values are higher than GREEN ones. Specifically, the minima values are, respectively, 214.87 and 100.25 for the non-pandemic period and 230.98 and 102.04 for the pandemic. The maxima ones, instead, are 244.60 and 111.29 before the pandemic and 249.03 and 110.04.

Figure 1 - Green and sovereign time series

Source: our elaboration

Each index presents non-normal distribution for both times, as testified by the significant Jarque-Bera tests.

Moreover, the Augmented Dickey-Fuller (ADF) tests for unit root are not significant, so all the series are not stationary. This issue is also clear by the graphics which present a trend for both the indices (Figure 1).

In order to apply the DCC-GARCH, series need to be stationary. For this purpose we have calculated the first differences verified the significance of the ADF tests.

Table 2 and 3 show the results of the DCC-GARCH respectively for the non and the pandemic period. The first three parameters are referred to the first step of the model, i.e. the univariate GARCH. In particular, ω represents the mean, α is the ARCH is parameter and β is the measure of the GARCH.

Specifically, before the pandemic, the ω parameter has a 10% significance for both series.

The ARCH and GARCH parameters are highly significant (1%) for both GREEN and SOV: therefore, respectively, the one-day lagged performance of each series affects its expected value while the β parameters testify the persistence in volatility.

As concerns the pandemic, the latter results are confirmed as well. At the same time, the ω and α are not significant for the green bond index: the latter result expresses the non sensitivity of this variable to its own value during the pandemic crisis.

With reference to sovereign bond market, instead, these parameters are significant respectively at 10% and 1%.

The second part of the tables display the two lambda parameters, the log-likelihood value and the information criteria. In particular the former are the expressions of the DCC-GARCH model as they measure the joint dynamic conditional correlations between the two indices, respectively for the short (λ_1) and long (λ_2) run.

Table 2 - DCC-GARCH Non-pandemic period

	GREEN	SOV
ω	0.000680* (0.000368)	0.005231* (0.002814)
α	0.033264*** (0.010125)	0.069933*** (0.024043)
β	0.951290*** (0.014191)	0.904297*** (0.031981)
λ_1	0.046104 (0.033106)	
λ_2	0.930485*** (0.066829)	
LogLik	93.14852	
AIC	-0.19060	
BIC	-0.12987	
HQC	-0.16735	

Standard error is indicated in parentheses. ***, **, * indicate statistical significance at 1%, 5%, 10% level, respectively

Source: our elaboration

Specifically, for both times, the λ_2 parameter is significant at 1%: so in the long-term, the green and sovereign bond markets are dynamically conditionally correlated, regardless of the presence of a turmoil. On the contrary, the λ_1 parameter is significant only for the pandemic period. We deem this result particularly interesting, since it testifies that the two markets show a short-term joint correlation only during the crisis: during the pandemic the respective sensitivity between the two kinds of bonds is higher as it is definitively more immediate.

All in all our results testify the long-run correlation between the green and sovereign bond markets: this finding is presents similarities with Li et al. (2021), who document a long-run relation between sovereign and corporate bonds. Moreover, our findings confirm a strict connection between the government and green bonds, as already demonstrated by other researchers (e.g. Reboredo & Ugolini, 2020; Reboredo, 2018): in this sense we observe that green bonds show a behavior quite similar to other

segment of the fixed income. Furthermore, in terms of asset allocation, green bonds do not seem to enhance the diversification of a sovereign portfolio, with the exception of the short run during “normal” times.

Table 3 - DCC-GARCH Pandemic period

	GREEN	SOV
ω	0.006631 (0.008342)	0.048021*** (0.021757)
α	0.102563 (0.075247)	0.167533* (0.092920)
β	0.803273*** (0.181957)	0.700628*** (0.110597)
λ_1		0.045581*** (0.013560)
λ_2		0.940302*** (0.018536)
LogLik		5.577455
AIC		0.024426
BIC		0.125899
HQC		0.064442

Standard error is indicated in parentheses. ***, **, * indicate statistical significance at 1%, 5%, 10% level, respectively

Source: our elaboration

4 Conclusions

The paper has analyzed the dynamic conditional correlations between the green and sovereign bond markets in Europe before and during the pandemic. The methodology adopted is the DCC-GARCH.

The main results show that during the pandemic period the two markets are significantly dynamically correlated both in the short and long run, while in the previous time the correlation is testified only in the long run. We deem these findings interesting under a portfolio construction point of view, as the two segments of the bond market can be allocated to diversify the portfolio only for short time investments during no crisis periods. All in all green bonds seem to present analogous behaviors with conventional bond, so they cannot be regarded as a different asset class, but they are fundamentally substitutes or supplements of more traditional fixed income securities. Notwithstanding they allow investors to integrate climate risk in their portfolios showing a risk-return profile to that of Treasury bonds (Ferrer et al., 2021).

The perspectives of future research could be twice: making a comparison with the American and Asian market and investigating the peculiarities of sovereign green bonds compared to conventional ones.

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