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Sovereign bonds and flight to safety: Implications of the COVID-19 crisis for sovereign debt markets in the G-7 and E-7 economies☆

Muhammad Ali Nasir [a,e,*], Thi Ngoc Lan Le [b], Yosra Ghabri [c], Luu Duc Toan Huynh [d]

[a] Department of Economics, University of Leeds, Leeds, UK
[b] University of Sydney, Australia
[c] Higher Institute of Finance and Taxation Sousse - Laboratory of Applied Economics and Finance, University of Carthage, Tunisia - Center of Research for Energy and Climate Change (CRECC), France
[d] Department of Business Analytics and Applied Economics, School of Business and Management, Queen Mary University of London, London, UK
[e] Department of Land Economy, University of Cambridge, Cambridge, UK

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ABSTRACT

This study investigates the implications of the COVID-19 pandemic for sovereign debt in the G-7 and E-7 economies and explores the notion of sovereign bonds as a safe haven. Using a set of panel regression and dynamic connectedness TVP-VAR approaches, our results reveal that the impact of COVID-19 global case numbers on sovereign bonds has been contingent on the level of the country's financial and economic development. More precisely, our findings suggest that G-7 countries, where economic development is typically higher, have seen a negative effect of the COVID-19 pandemic on sovereign bond yield: sovereign 10-year bond yields declined as the number of COVID-19 global confirmed cases increased in G-7 countries. However, in E-7 countries, where economic growth and development are typically lower, sovereign bond yields responded positively to the initial increase in COVID-19 global confirmed case numbers, but this positive effect is not statistically significant. We also find that the G-7 and E-7 economies have a strong time-varying connectedness in relation to their bond markets and this effect is more pronounced in G-7 economies. Daily Infectious Disease Equity Market Volatility is likely to be the strongest predictor of total connectedness. Concomitantly, we shed new light on the predictive power of the number of COVID-19 confirmed cases and deaths, and the Daily Infectious Disease Equity Market Volatility Tracker on the interdependence of these sovereign bond markets. Overall, this paper highlights the heterogeneous effect of the COVID-19 pandemic on sovereign bond yields in G-7 and E-7 countries and the notion that the developed economies, with their developed sovereign bond markets, are still seen as a safe haven during times of crisis.

1. Introduction

The COVID-19 pandemic will go down in history as one of the most significant events of the 21st century. It has had severe consequences for the global economy and financial markets and government borrowing has sky-rocketed, with implications for long-term fiscal sustainability (IMF, 2020).[1] With the outbreak of the pandemic, emerging economies were a particular point of concern in terms of capital flight and long-term fiscal sustainability (Kose, Nagle, Ohnsorge, & Sugawara, 2020). As the pandemic hit the headlines in March 2020, the Institute of International Finance (IIF) reported that large emerging economies suffered cross-border capital outflows of over $100bn. Though the outlook improved thereafter, as the epicentre of the pandemic shifted from Asia to Western Europe and the USA, to some, the risks of capital flight

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* Corresponding author at: Leeds University Business School, Leeds LS2 9JT, UK.
E-mail address: m.a.nasir@leeds.ac.uk (M.A. Nasir).

[1] Undoubtedly, the fiscal support provided by governments across the world was helped to stabilize the global economy and financial system: see Jiang, Wu, Tian, and Nie (2021) and Zaremba, Kizys, Tzouvanas, Aharon, and Demir (2021).

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remained high (IIF, 2020). At the time of writing, however, over a year since the outbreak of the pandemic, capital flight has not occurred. Moreover, with the widespread implementation of vaccination programmes, it might be the case that the emerging economies will never see capital flight resulting from COVID-19. However, at this juncture, there are still questions regarding the stability of the emerging and developed economies, particularly their sovereign bonds market and how they have performed during the pandemic. Therefore, empirical analysis to explore the effect of COVID-19 on sovereign bond markets in advanced and in emerging economies is intriguing.

It is commonly believed that sovereign debt may be less risky than private-sector debt because governments have the power of taxation to raise funds and pay their bills. It has also been generally argued that the borrowing costs for governments depend on the macroeconomic and financial conditions of the national economy, especially government finances (see e.g., Aizenman, Pinto, & Sushko, 2013; Ardagna, Caselli, & Lane, 2007; Attinasi, Checherita-Westphal, & Nickel, 2009; Baldacci & Kumar, 2010; Beirne & Fratzscher, 2013; Ghosh, Ostry, & Qureshi, 2013), which in turn establishes the nexus between fiscal sustainability and the cost of borrowing manifested in sovereign bond spreads (Capelle-Blancard, Crifo, Diaye, Oueghlissi, & Scholtens, 2019). This nexus has been consistently confirmed by several studies in the context of environmental, social and governance (ESG) criteria, along with the common purpose of returns and portfolio diversification (Bénabou & Tirole, 2010; Kitzmueller & Shimshack, 2012). Governments with large public deficits and high debt are riskier, and thus investors require a higher return on sovereign debt. Government borrowing costs through bonds are also associated with fiscal prudence. This prudence is reflected in the flexibility of an economy and its growth capacity, the transparency of information, as well as a country's fiscal credibility and commitment to responsible borrowing, all of which can be found in advanced economies, notably the G-7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States), where the levels of development of the underlying economies as well as of the financial markets are high. In consequence, these countries are deemed to have a lower likelihood of defaulting on their debt obligations (Eaton & Gersovitz, 1981; Nelson, 2011; Papanikos, 2014). Furthermore, these advanced market economies prefer to keep their debts in check, in order to build a good reputation in the capital markets. A good reputation allows governments to continue to borrow at comparatively low interest rates.

The sovereign bonds of emerging markets (EM) have steadily increased in popularity and importance, particularly since the Global Financial Crisis of 2008–09 and the euro-zone sovereign debt crisis that emerged thereafter (Nasir & Du, 2018). This has also been a period when yields on EM government bonds moved closely in tandem with the US Treasury yield, which is widely accepted as the risk-free global benchmark yield. This raises questions about the underlying factors and drivers of foreign investors' interest in emerging markets, especially the Emerging 7 or E-7 (i.e., China, India, Brazil, Russia, Indonesia, Mexico, and Turkey). As it stands, there are different points of view. For instance, diversification of portfolio is one of the main reasons given for institutional investors to choose EM government bonds; they also offer higher risk-adjusted returns (Monetary and Capital Markets Department, 2011). The consistently improved domestic institutions, macroeconomic outlook, monetary policies and market infrastructures of these economies (see e.g., Claessens, Klingebiel, & Schmukler, 2007; Gagnon, 2014; Goldstein & Turner, 2004; Mohanty, 2012; Montoro & Rojas-Suarez, 2012; Turner, 2012) have provided good investment opportunities for institutional investors. According to Min, Lee, Nam, Park, and Nam (2003), such improvements in the emerging markets have overcome the "original sin" problem, the notion that the domestic currency cannot be used to borrow abroad or to borrow long term even domestically, which is often a problem in the emerging markets (see Eichengreen, Hausmann, & Panizza, 2002). There are two principal arguments regarding whether the benefits from diversification through investment in EM government bonds can outweigh the inherent volatility in EM exchange rates (Burger & Warnock, 2007; Turner, 2012). First, it is suggested that for their growth, emerging countries depend on continuous inflows of funds from international bond markets. However, government bonds in these emerging markets tend to be more vulnerable than those in advanced economies, since these markets are associated with higher debt, fewer available sources to repay debt, and vulnerable political systems (Guercio & Gómez, 2011). Second, it is argued that developing and newly developed countries tend to be dominated by stronger foreign currencies, such as the US dollar and the euro, and therefore any deterioration in local currency will lead to an upsurge in debt because it is denominated in the foreign currency. The advanced economies, including the G-7, by contrast, can borrow in their domestic currency without this currency risk, and thus sovereign debt in advanced economies has generally been more stable than that in emerging markets; as a result, they are likely to be associated with lower yields.

There is plentiful empirical literature on the determinants of long-term bond yield in advanced economies, mostly drawing on data from the US, Europe and OECD countries, related to higher fiscal deficits and public debt. These studies have indicated that fiscal deficits escalate the cost of borrowing (Faini, 2006; Gale & Orszag, 2003; Haugh, Ollivaud, & Turner, 2009; Laubach, 2009). Several studies have investigated the determinants of the yield on EM sovereign bonds. These have included: external vulnerability, like external debt, debt service, or current account position (Cantor & Packer, 1996; Edwards, 1983); fiscal debt and deficits (Rowland & Torres, 2004); and macroeconomic outlook (Min, 1999). Moreover, studies that considered emerging markets (Peiris, 2010) and those that jointly considered advanced and emerging economies (Baldacci & Kumar, 2010) have established that long-term yields are associated with the movements in policy interest rates, inflationary expectations, foreign participation in domestic bond markets and expectations of short-term interest rates. A remarkable study on 22 emerging and developed countries by Smaoui, Grandes, and Akindele (2017) reported that structural, financial and institutional factors affect the development of the bonds market in both groups. In general, the fiscal outlook is mostly associated with the dynamics of EM bond yields (Miyajima, Mohanty, & Chan, 2015). Other factors, such as global risk aversion (Bellas, Papaioannou, & Petrova, 2010; Eichengreen & Mody, 1998; McGuire & Schrijvers, 2003) and global liquidity (Dailami, Masson, & Padou, 2005; González-Rozada & Yeyati, 2008; Hartelius, Kashiwase, & Kodres, 2008), also play role in determining sovereign bond yield spreads. Additionally, periods of financial distress with high inflationary pressures, more adverse global liquidity conditions, and fiscal deterioration can affect bond yields (Baldacci & Kumar, 2010).

During times of crisis, government bonds are characterised by higher default risk and, as a result, investors may want to seek a higher yield. Consequently, the differences in the yield offered on the bonds issued by different governments are explained by variations in international risk factors (Codogno, Favero, & Missale, 2003), credit risk (Geyer, Kossmeier, & Pichler, 2004), and liquidity risk spreads (Bernoth & Erdogan, 2012; Favero, Pagano, & Von Thadden, 2010; Gomez-Puig, 2006; Jankowitsch, Mosenbacher, & Pichler, 2006). Given that the COVID-19 pandemic has had profound adverse socio-economic and financial consequences, it has represented a significant risk to emerging as well as developed economies. Therefore, it is intriguing to analyse its implications for the sovereign bond markets of both.

In comparison with other financial assets, sovereign bonds are perceived to be safer investments in both advanced and emerging markets and hence are often considered a "safe haven" (Chan, Treepongkaruna, Brooks, & Gray, 2011; Fleming, Kirby, & Ostdiek, 1998; Hartmann, Straetmans, Vries, & d., 2004; Noeth & Sengupta, 2010), contributing to well-diversified portfolio allocations and providing hedging benefits during a crisis. The "flight to quality" phenomenon is when assets believed to be safe havens perform better during times of crisis since investors want to reduce their risky equity holdings and replace them with investments in safe assets. This proposition has

motivated a burgeoning strand of the safe-haven literature, which suggests that safe-haven assets include sovereign bonds (Andersen, Bollerslev, Diebold, & Vega, 2007; Baele, Bekaert, & Inghelbrecht, 2010), Forex, for instance, the Japanese yen, Swiss franc, British pound and the euro (Habib & Stracca, 2012; Ranaldo & Söderlind, 2010), different kinds of stock (Huynh, Nasir, & Nguyen, 2020), and commodities such as gold (Baur & Lucey, 2010; Thampanya, Nasir, & Huynh, 2020), silver and platinum (Hillier, Draper, & Faff, 2006).

Analysis of safe-haven assets is closely associated with a strand of literature that has examined contagion effects, that is, effects which strongly co-move across different markets in times of turmoil (Forbes & Rigobon, 2002; Nasir & Du, 2018). These contagion effects are likely to undermine the stability of the global financial system, and thus push investors to seek safe-haven assets during periods of crisis. Investors tend to replace equity holdings with bonds following adverse market shocks (Hartmann et al., 2004). Those safe-haven assets may be used as "quality" assets in times of severe financial instability, and this validates the importance of these assets. These studies have argued that a thorough examination of assets commonly believed to be safe havens will be of significant practical importance to investors and other participants in the financial markets.

In the context of the debate on sovereign bonds as a safe haven and the notion of emerging economies joining the safe-haven bond club traditionally the reserve of the developed economies, we analysed the dynamics of sovereign bond markets over seven months from the outbreak of the COVID-19 pandemic, which has caused unprecedented levels of uncertainty in the global financial markets (Bouri, Demirer, Gupta, & Pierdzioch, 2020; Cakici & Zaremba, 2021; Goodell, 2020; Yarovaya, Matkovskyy, & Jalan, 2021), and which is considered to have marked the worst economic downturn since the Great Depression (Caggiano, Castelnuovo, & Kima, 2020). This is manifested in the huge fluctuations in the financial markets, which plunged to their lowest since the Global Financial Crisis (GFC) of 2008–2009 (Bouri, Cepni, Gabauer, & Gupta, 2021; Elnahass, Trinh, & Li, 2021; Zhang, Hu, & Ji, 2020), and which has been worse than any associated with a previous outbreak of an infectious disease (Baker et al., 2020a). Nevertheless, the combined health and economic crisis resulting from the COVID-19 pandemic and its adverse effects on all sectors of the economy provides a unique research setting to examine whether sovereign bonds in advanced economies (G-7) and emerging economies (E-7) played a safe-haven role during the flight to safety and acted as protectors against losses in the wake of increased financial and economic uncertainty. During the observation period of the present study, were sovereign bonds in emerging markets seen as equally safe or even safer than those in advanced economies, due to the lower numbers of confirmed cases of COVID-19 in those emerging economies? This can be gauged through the impact of COVID-19 on bond yields as the higher demand and flight of capital to sovereign bonds lower their yields. If these sovereign bonds are seen as safe havens, then, during the COVID-19 pandemic, the demand for them should increase, to hedge against financial market uncertainties and fluctuations, resulting in a rise in prices and a corresponding fall in their yields.

From the review of the evidence on the determinants of sovereign bonds in both developed and developing countries, as well as diversified safe-haven assets during periods of turmoil, it is evident that no previous study has: (a) examined the sovereign bond yields' response to the COVID-19 pandemic in terms of global and country-level numbers of confirmed cases in the context of G-7 and E-7 countries; (b) investigated whether and how a country's levels of economic and financial development affect the relationship between the sovereign bond market and the COVID-19 pandemic and specifically if the E-7 economies' sovereign bonds markets are comparable to those of their G-7 counterparts; (c) analysed the time-varying connectedness among the sovereign bond markets in G-7 and E-7 economies; and (d) has analysed the predictive power of the numbers of COVID-19 confirmed cases and deaths, and the Daily Infectious Disease Equity Market Volatility Tracker on the interdependence of these sovereign bond markets. These are the four respects in which this study contributes to the existing literature. In so doing, it has employed a set of panel regression and dynamic connectedness TVP-VAR approaches. Our results reveal that the impact of COVID-19 global case numbers on sovereign bonds is contingent on the level of the country's financial and economic development. More precisely, our findings suggest that G-7 countries, where economic development is typically higher, have seen a negative effect of the COVID-19 pandemic on sovereign bond yield. This result indicates that sovereign 10-year bond yields declined as the number of COVID-19 global confirmed cases increased in the G-7 countries. However, in the E-7 countries, where the levels of economic growth and development are typically lower, sovereign bond yields responded positively to the increase in COVID-19 global confirmed case numbers, but this positive effect is not statistically significant. We also found that the G-7 and E-7 have a strong time-varying connectedness and the effect is more pronounced in G-7 economies. Concomitantly, we shed new light on the predictive power of the numbers of COVID-19 confirmed cases and deaths, and the Daily Infectious Disease Equity Market Volatility Tracker on the interdependence of these sovereign bond markets. Overall, this paper highlights the heterogeneous effect of the COVID-19 pandemic on sovereign bond yields in G-7 and E-7 countries and the notion that the developed economies, with their developed sovereign bond markets, are still counted upon during times of crisis.

Table 1
Date of outbreak: first confirmed case of COVID-19.

G-7 countries	First COVID-19 case confirmation date		
	Date	E-7 countries	Date
Canada	Jan 26, 2020	Brazil	Feb 26, 2020
France	Jan 24, 2020	China	Jan 4, 2020
Germany	Jan 27, 2020	India	Jan 30, 2020
Italy	Jan 31, 2020	Indonesia	Mar 02, 2020
Japan	Jan 22, 2020	Mexico	Feb 28, 2020
UK	Jan 31, 2020	Russia	Jan 31, 2020
US	Jan 22, 2020	Turkey	Mar 11, 2020

The remainder of the paper proceeds as follows: Section 2 discusses the empirical approach and chosen methodology. Section 3 discusses the results. Section 4 concludes and provides some policy implications.

2. Data and methodology

2.1. Data

We employed daily data on COVID-19 global and country-level numbers of confirmed cases, yields of publicly-traded 10-year sovereign bonds, interest rates, exchange rates, stock market returns[2] and market capitalization[3] for G-7 and E-7 countries. The bond data are obtained from Bloomberg and start from December 31, 2019, and end on August 7, 2020. COVID-19 global and country case data are collected from the daily reports published by the World Health Organization (WHO) for the same period. We matched the daily 10-year sovereign bonds' yield data with country-level control variables and the daily

[2] We used the benchmark stock market index for each G-7 and E-7 country: S&P/ TSX composite index, which is the benchmark Canadian index; CAC 4 for France; DAX stock Exchange Index for Germany; FTSE MIB, the benchmark stock market index for Italy; NKY- Nikkei 225 for Japan; FTSE 100 Index for the UK; S&P 500 for the US; BOVESPA, the Brazil Stock Exchange; Shanghai Stock Exchange for China; SENSEX Index, the Indian national stock market exchange; JCI, Jakarta Stock exchange composite for Indonesia; S&P BMV IPC for the Mexican Stock market; MOEX Russia Index; Borsa Istanbul 100 Index for Turkey.

[3] Market capitalization is calculated as the natural logarithm of the market capitalization for the stock market in each G-7 and E-7 country.

Table 2
Summary of descriptive statistics.

Variable	Mean	Standard deviation	Minimum	Maximum
SBY	2.732	2.769	−0.858	9.643
Growth GC	0.108	0.287	0.000	4.621
Growth CC	0.132	0.776	−0.005	7.125
INTR	2.802	2.968	−0.100	12.000
EXCHR	82.785	26.759	24.04	132.55
SMR	−0.000	0.022	−0.169	0.137
NLMC	16.261	3.062	4.314	24.772

Notes: Total number of observations = 2226.

COVID-19 data. To refine the data, we eliminated observations with missing values because sovereign bond yield data are not available for weekends; however, COVID-19 global case data are available for each day. After applying this adjustment, our final dataset includes 2226 observations covering all 14 countries. Table 1 presents the date of the outbreak in each country i.e., the date when the first COVID-19 case was confirmed.[4]

It would be cogent to argue that the outbreak might be a bit earlier than the official recognition and confirmation of the cases; however, we rely on the official statistics and take them as the starting point of the pandemic for each country. Table 2 presents a summary of descriptive statistics of the underlying variables between December 31, 2019, and August 7, 2020. SBY is the measure of the daily 10-year sovereign bond yield of a country. Growth in global case numbers (Growth GC) is measured as the daily growth in COVID-19 globally confirmed cases. Growth in in-country case numbers (Growth CC) is measured as the daily growth in the number of confirmed cases within a country. INTR is the daily policy interest rate. EXCHR is the effective exchange rate measured as national currency units against a basket of currencies. SMR is the stock market return measured as the daily change in the stock index of a country. NLMC is the measure of market capitalization calculated as the natural logarithm of daily market capitalization.

Table 2 shows that on average over the study period, G-7 and E-7 countries had a 10-year sovereign bond yield of 2.732% with a standard deviation of 2.769%. It can be seen that the minimum daily sovereign bond yield during the period was −0.858% and the maximum was 9.643%. Fig. 1 displays the evolution of sovereign 10-year bond yields for the G-7 and E-7 countries during the study period. The average growth in the daily numbers of global confirmed cases was 10.80% and the average growth in the daily country confirmed cases was 13.20%. The mean value of the interest rate was about 2.80%, the maximum natural logarithm of daily market capitalization was 24.77, with an average stock market return of −0.000 and the mean exchange rate was 82.785.

Fig. 1 depicts the evolution of sovereign bond yields of the G-7 and E-7 countries over the period. While, overall, the E-7 countries initially showed a drop in yield, the pattern varied among them. Germany showed a negative yield, a manifestation of the strength of German Bunds and German fiscal prudence. In contrast, Italy showed an initial slight increase, indicating the fiscal stress that Italy has been facing since the onset of the European sovereign debt crisis. French and Japanese yields also showed a negative response, While although UK, US and Canadian bonds yields did not turn negative, they still decreased significantly. So on the whole, almost all G-7 countries showed a decline in the sovereign bond yield around the outbreak of COVID-19.

As compared to the G-7, the yield on the sovereign bonds of the E-7 countries also showed an initial decrease but thereafter some increase over the period of analysis. There were also some differences between countries. This could be associated with differences in their fiscal outlook and also calming of the financial markets to some extent as the situation started to improve and case numbers started to decrease, particularly in China. The Chinese sovereign bonds yield decreased consistently for the first half of the sample and then increased again. A bit similar pattern was observed in Indonesia, Russia, and Turkey. However, in the case of India, the sovereign bonds yield consistently decrease, whereas in the case of Mexico, it decreased at the later part of the period of analysis. Interestingly, the Brazilian sovereign bond yield increased when the Mexican sovereign bonds yield was decreasing. This can be associated with the break of the Pandemic in the Latin American region and also the portfolio adjustment and the fiscal outlook of Brazil and Mexico. The causal analysis in the following section will shed further light on this.

2.2. Methodology

This study employed panel approaches to estimation to investigate the impact of COVID-19 global as well as domestic case numbers on sovereign bond yields. Because the pandemic is ongoing and is not a one-point-in-time event, we do not use the classical event study approach. The employed panel data analysis explores both time series and cross-sectional variation, examines the time-varying relationship between dependent and independent variables, controls for individual heterogeneity and reduces the problems of heteroscedasticity, multicollinearity and estimation bias (see Ashraf, 2017; Baltagi, 2008; Hsiao, 2014). The nexus between the sovereign bond yields and its explanatory variables, including COVID-19 case numbers, can be specified in the following form:

$$SBY_{i,t} = \alpha_i + \beta_1\, COVID-19_{i,t-1} + \sum_{k=1}^{k} \beta_k\, X_i^k + \varepsilon_{i,t} \quad (1)$$

where $SBY_{i,t}$ is the 10-year sovereign bond yield for a country i on day t, and COVID-19 represents the lagged value of (1) daily growth in total confirmed global case numbers (Growth GC) and (2) daily growth in the total number of confirmed domestic cases (Growth CC). X_i^k is a vector of country-specific control variables, including interest rates (INTR), exchange rate against the US dollar (EXCHR), stock market returns (SMR) and the natural logarithm of daily market capitalization (NLMC). $\varepsilon_{i,t}$ are the residuals.

This study also employs the TVP-VAR approach (time-varying parameter–vector autoregression) used by Antonakakis, Chatziantoniou, and Gabauer (2020) and Foglia and Dai (2021) to capture both static and dynamic connectedness. This approach is particularly useful in capturing the spillover effects of sovereign bond markets. TVP-VAR is an innovative approach that incorporates time-varying effects, following the Diebold and Yılmaz (2014) method. There are two main reasons for choosing the TVP-VAR approach. First, our model outperforms others in terms of mitigating the missing observations when using the rolling window size. Therefore, it is not sensitive to the rolling window size. Second, the outlier problem is less likely to cause severe bias in our model selection. More importantly, our data on COVID-19 has a limited time horizon, as the pandemic hopefully will not persist over the long term. Therefore, the TVP-VAR seems ideal.

We start with the following traditional specification:

$$Y_t = \beta_0 + \beta_t Y_{t-1} + \varepsilon_t \quad (2)$$

$$vec(B_t) = vec(B_{t-1}) + \vartheta_t \quad (3)$$

in which the dependent variable for model (1) is the vector of endogenous variables which are determined at time t. β_t is a set of N × N time-varying parameters, presented in matrix form. The remaining residual ε_t and ϑ_t are supposed to follow $N(0, S_t)$ and $N(0, R_t)$ and when the size of matrix is N × 1 they are vectors of the error terms. The two new terms (S_t) and (R_t) are the time-varying variance-covariance matrix. In our study, the set of variables is the group of all G-7 and E-7 bond yields. In the following steps, we applied the Generalized Forecast Error

[4] The COVID-19 confirmed case data for each country starts from this date in our sample.

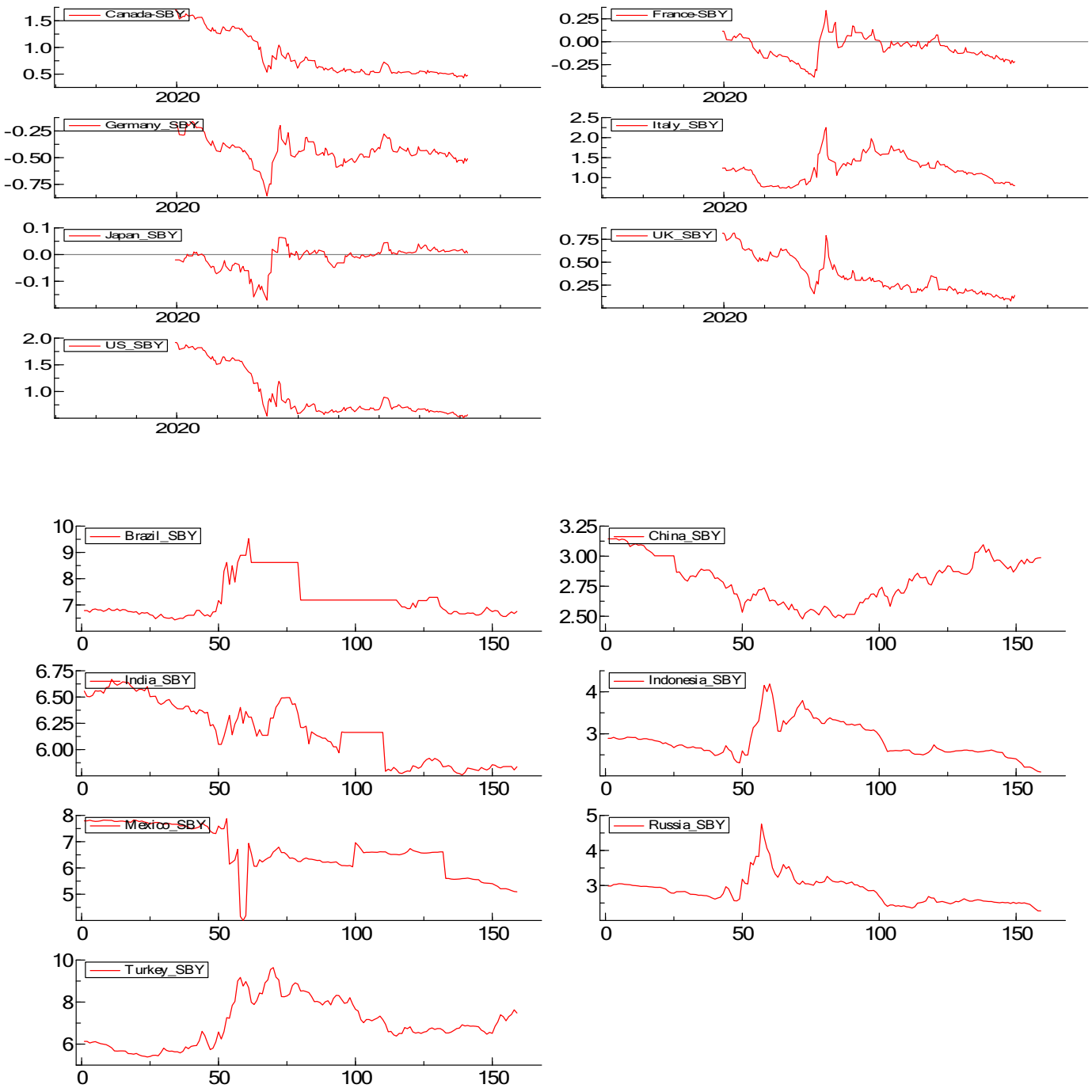

Fig. 1. Dynamics of sovereign bond yields (31st December 2019 – 7th August 2020) of the G-7 and E-7 countries.

Variance Decomposition (GFEVD; Koop, Pesaran, & Potter, 1996; Pesaran & Shin, 1998). Thus, the TVP-VAR model was transformed into a TVP-VMA (Time-varying parameter Vector of Moving Average) model, which can be written as:

$$Y_t = \sum_{i=1}^{p} \beta_{it} Y_{t-i} + \varepsilon_t \quad (4)$$

Model (4) is specified as:

$$Y_t = \sum_{j=1}^{\infty} A_{jt} \varepsilon_{t-j} \quad (5)$$

in which A is the vector of time-varying parameters from the moving average process. The details of the calculation of each indicator (e.g. total connectedness, from-connectedness, and net-connectedness) are presented by Huynh et al. (2020) and Pham and Huynh (2020).

After estimating these models, we extract the total connectedness for all G-7 and E-7 countries to see how these markets are interconnected with each other. Thereafter, we use the growth rate in COVID-19 case and death numbers, and the Daily Infectious Disease Equity Market Volatility Tracker to examine their predictive power. The model is specified as follows:

$$Total\ connectedness_t = \beta_0 + \beta_1 COVID\_indicator_t + \beta_z Control + \varepsilon_t \quad (6)$$

where the total connectedness is obtained from the previous model estimations. COVID-19 indicators are the growth rates in COVID-19 confirmed case and death numbers and the Infectious Disease Equity

Table 3
COVID-19 Pandemic and Sovereign bonds market.

Variables	Sovereign bond yield (SBY)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Growth GC	−0.138	0.122**			
	(0.111)	(0.045)			
Growth CC			−0.040	−0.054**	0.013*
			(0.227)	(0.033)	(0.067)
INTR	0.582***	0.553***	0.576***	0.576***	0.562***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EXCHR	−0.027***	−1.035*	−0.032***	−0.032***	−0.026*
	(0.000)	(0.060)	(0.000)	(0.000)	(0.055)
SMR	1.359 (0.451)	1.347***	1.603	1.603	1.589***
		(0.001)	(0.439)	(0.402)	(0.002)
LNMC	−0.090***	−0.071**	−0.082***	−0.082***	−0.065**
	(0.000)	(0.046)	(0.000)	(0.000)	(0.048)
Day effect	No	No	No	Yes	No
Country effect	No	Yes	No	No	Yes
Constant	4.838***	4.838**	4.821***	4.821***	4.821**
	(0.000)	(0.037)	(0.000)	(0.000)	(0.043)
Observations	2226	2226	2226	2226	2226
R-squared	0.694	0.695	0.587	0.596	0.596

Note: The values in parentheses are p-values based on robust standard errors that are clustered by country and day. VIF values do not indicate the multi-collinearity problem. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.

Market Volatility index by Baker et al. (2020b). Control variables are the MSCI World index, gold, and crude oil returns.

3. Results

3.1. COVID-19 and sovereign bond markets

To analyse the relationship between COVID-19 and sovereign bonds, we employ panel estimation and the results are summarized in Table 3. To start with, we estimate Eq. (1) to examine the sovereign bond yields' response to the growth in COVID-19 case numbers for all countries, using Ordinary Least Squares (OLS) regression with robust standard errors.[5] This shows that sovereign bond yields are negatively and not significantly related to the daily COVID-19 global confirmed case numbers. To assess the effect of cross-country variations in COVID-19 confirmed case numbers on the yields of sovereign bonds, the second specification includes country-fixed effects to control for country-specific unobservable heteroscedasticity. These findings contrast with those found with the first specification: there is a positive effect of daily growth in COVID-19 confirmed cases on sovereign 10-year bond yields at the 10% level of significance. This suggests that the impact of the COVID-19 pandemic on sovereign bond yields is influenced by country-specific differences in economic growth and development.

Regarding the control variables, our results show that the coefficient on the interest rate (INTR) is positive and significant at the 1% level for the three specifications. Second, the exchange rate against USD (EXCHR) is significantly negative in all the specifications. In addition to that, the daily market capitalization (LNMC) is negative and significant, whereas the coefficient on daily stock market returns is significantly positive (at the 1% level) only when we control for country-fixed effects. To control for daily international events and systematic risk due to international factors and to understand the changing effect of the COVID-19 pandemic over time, the fourth specification includes daily fixed effects. The regression results show that the effect of daily growth in the domestic number of COVID-19 cases becomes significantly negative at the 1% level. The findings shown in column 4 suggest that the daily fixed effect has a significant impact on the negative relationship between the growth in domestic COVID-19 case numbers and sovereign bond yields. Specifically, this result indicates that the response of sovereign bond yield varies over time depending on the growth in domestic COVID-19 case numbers. Finally, the regression results on the effect of domestic COVID-19 case numbers (Models 3 and 5) are qualitatively like those related to COVID-19 global case numbers.

Table 4
COVID-19 and sovereign bonds market, G-7 and E-7.

Variables	Sovereign bond yield (SBY)	
	Model 1	Model 2
Growth GC	0.054***	
	(0.001)	
Growth CC		0.036***
		(0.000)
G-7-E-7	4.137***	4.123***
	(0.000)	(0.000)
INTR	0.035***	0.038***
	(0.000)	(0.000)
EXCHR	−0.022***	−0.018***
	(0.000)	(0.000)
SMR	0.413	0.448
	(0.742)	(0.722)
LNMC	−0.232***	−0.221***
	(0.000)	(0.000)
Constant	6.174***	6.163***
	(0.000)	(0.000)
Day effects	No	Yes
Country effects	Yes	Yes
Observations	2226	2226
R squared	0.716	0.715

Note: The values in parentheses are p-values based on robust standard errors that are clustered by country and day. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.

To what extent does the level of economic growth and development have an impact on the relationship between the growth in COVID-19 global cases and sovereign bond yields? To answer this question, we add a dummy variable (G-7-E-7) relating to the economic growth and development of a country and we separately regress each of the two main independent variables (Growth GC, G-7-E-7) on sovereign bond yield (SBY). The dummy variable G-7-E-7 is equal to unity if the country belongs to the E-7 economies and 0 otherwise. The results are reported in Table 4.

The regression results reported in column 1 of Table 4 shows that the two explanatory variables (Growth GC and G-7-E-7) are positively and significantly correlated with 10-year sovereign bond yields. These

[5] The standard errors are robust to heteroskedasticity, cross-sectional dependence, and serial correlation.

Table 5
G-7 versus E-7 countries.

Dependent variable: SBY	G-7 countries	E-7 countries
Growth CC	−0.007***	0.131
	(0.001)	(0.101)
INTR	0.650***	0.160***
	(0.000)	(0.000)
EXCHR	−0.005***	−0.036***
	(0.000)	(0.000)
SMR	1.268**	-1.030
	(0.031)	(0.619)
LNMC	−0.045***	- 0.306***
	(0.000)	(0.000)
Constant	0.348***	3.549***
	(0.000)	(0.000)
Day effects	Yes	Yes
Country effects	Yes	Yes
Observations	1113	1113
R squared	0.587	0.532

Note: The values in parentheses are p-values based on robust standard errors that are clustered by country and day. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 6
Robustness check.

Dependent variable: SBY	All countries	G-7 countries	E-7 countries
Growth CC	0.121**	−0.003***	0.147
	(0.035)	(0.011)	(0.185)
G-7-E-7	2.734***		
	(0.000)		
INTR	0.141***	0.467***	0.181***
	(0.000)	(0.000)	(0.000)
EXCHR	−0.724***	−0.004***	−0.027***
	(0.000)	(0.003)	(0.000)
SMR	0.231	1.136***	−0.984
	(0.482)	(0.000)	(0.736)
LNMC	−0.067***	- 0.052***	−0.011***
	(0.000)	(0.000)	(0.000)
Constant	5.116***	1.517***	4.336***
	(0.000)	(0.000)	(0.000)
Daily effects	Yes	Yes	yes
Country effects	Yes	Yes	yes
Observations	2226	1113	1113
R squared	0.533	0.434	0.457

Notes: The values in parentheses are p-values based on robust standard errors that are clustered by country and day. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.

findings contrast those in Table 3, which shows a negative relationship between growth in COVID-19 global cases and sovereign bond yields. This is explained by the introduction of the dummy variable (G-7-E-7). Furthermore, the results indicate that the G-7-E-7 dummy variable is positively related to sovereign bond yield at the 1% level of significance. That is, the E-7 countries have higher sovereign bond yields than the G-7 countries. More precisely, in the E-7 economies, the COVID-19 global case numbers have a positive effect on sovereign bond yield. Hence, the effect of the COVID-19 pandemic on sovereign 10-year bond yields depends on the country's level of economic growth and development. The effect of the growth in domestic COVID-19 case numbers after adding the dummy variable G-7-E-7 remains similar to the effect of COVID-19 global case numbers.

To verify these results and to better understand how G-7 and E-7 countries see a different effect of COVID-19 case numbers on sovereign bond yield, we separately analyse the G-7 and E-7 groups of countries. The results are summarized in Table 5.

The results show that the growth in domestic COVID-19 case numbers is negatively and significantly related to sovereign bond yields in the G-7 countries, while in E-7 economies the growth in domestic case numbers is positively but not significantly related to sovereign bond yields. This finding suggests that the effect of the COVID-19 pandemic on sovereign bonds varies according to the level of development of a country. Specifically, it indicates that G-7 countries, where economic development is typically higher, exhibit a negative relationship between growth in COVID-19 confirmed cases and sovereign bond yields, whereas E-7 countries, where economies and financial markets are developing, see a positive link between COVID-19 cases and sovereign bond yields, although the positive effect is not statistically significant.

To confirm our main results, we perform several robustness tests. Specifically, we repeat all specifications of Tables 4 and 5 using the random-effects regression method. The regression results are presented in Table 6; they are qualitatively similar to those reported in Tables 4 and 5. (See Table 7.)

Table 7
The test of structural break.

Testing with COVID-19 severity	Bai & Perron critical values	Estimated break point
Global cases	UDmax(τ) = 97.71	11th March 2020 16th April 2020 19th May 2020
Country cases	UDmax(τ) = 94.31	11th March 2020 16th April 2020 19th May 2020

Notes: 1% Critical Value (4.50); 5% Critical Value (3.68); and 10% Critical Value (3.30).

Table 8
COVID-19 pandemic and sovereign bonds market after controlling for structural breaks.

Dependent variable: SBY	All countries	G-7 countries	E-7 countries
Growth CC	0.012**	−0.007***	0.068**
	(0.023)	(0.002)	(0.046)
G-7-E-7	3.777		
	(3.178)		
INTR	0.086	0.475**	−0.317
	(0.248)	(0.040)	(0.279)
EXCHR	−0.029**	0.008***	0.015**
	(0.024)	(0.009)	(0.043)
SMR	−0.133	1.306***	0.372
	(0.721)	(0.002)	(1.074)
LNMC	0.011***	−1.630 (1.246)	−0.002**
	(0.011)		(0.019)
Constant	3.221**	24.146***	9.993***
	(0.036)	(0.002)	(0.001)
Daily effects	Yes	Yes	Yes
Country effects	Yes	Yes	Yes
Structural break	Yes	Yes	Yes
Observations	2226	1113	1113
R squared	0.979	0.965	0.952

Notes: The values in parentheses are *p*-values based on robust standard errors that are clustered by country and day. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. The control for structural break can be done with a dummy variable for three sub-sample groups (before 12th March 2020, from 12th March 2020 to 16th April 2020, from 17th April 2020 to 19th May 2020, after 19th May 2020). The baseline is the period before 12th March 2020.
Notes: We choose the optimal lag selection based on three criteria: AIC, HQIC, and SBIC. Then the horizontal window and forecast horizon cover 45 days.

3.2. Robustness analysis with structural break

In order to test the robustness of our estimates further, we perform the analysis with a structural break, using the approach introduced by Ditzen, Karavias, and Westerlund (2021). The null hypothesis is that there is no structural break in the panel data of G-7 and E-7 economies while the alternative is that there is at least one structural break. We test the number of structural breaks in our sample for both scenarios (the growth of global cases and country cases). Interestingly, our results are

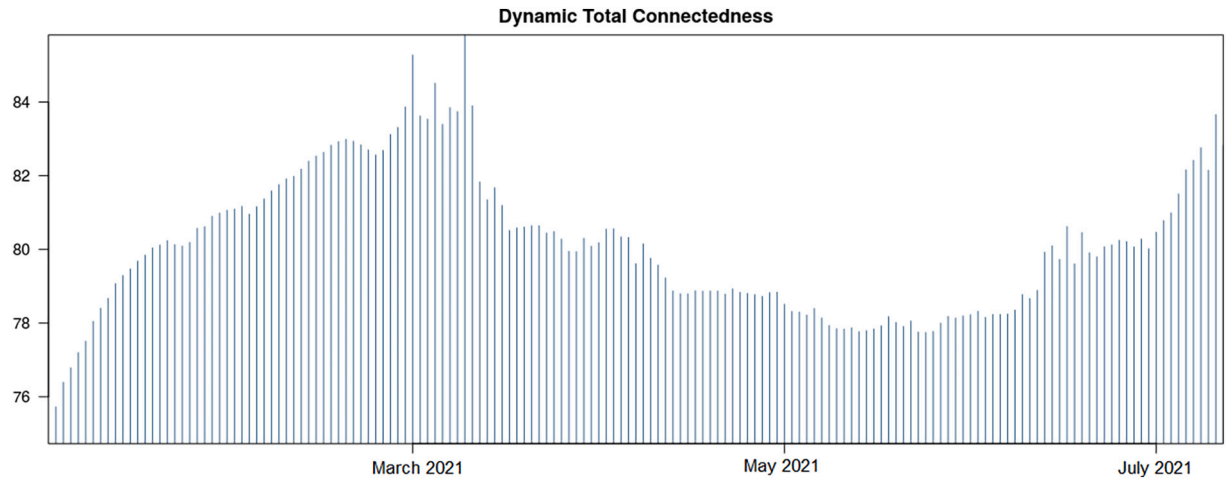

Fig. 2. The total connectedness of sovereign bond yield.

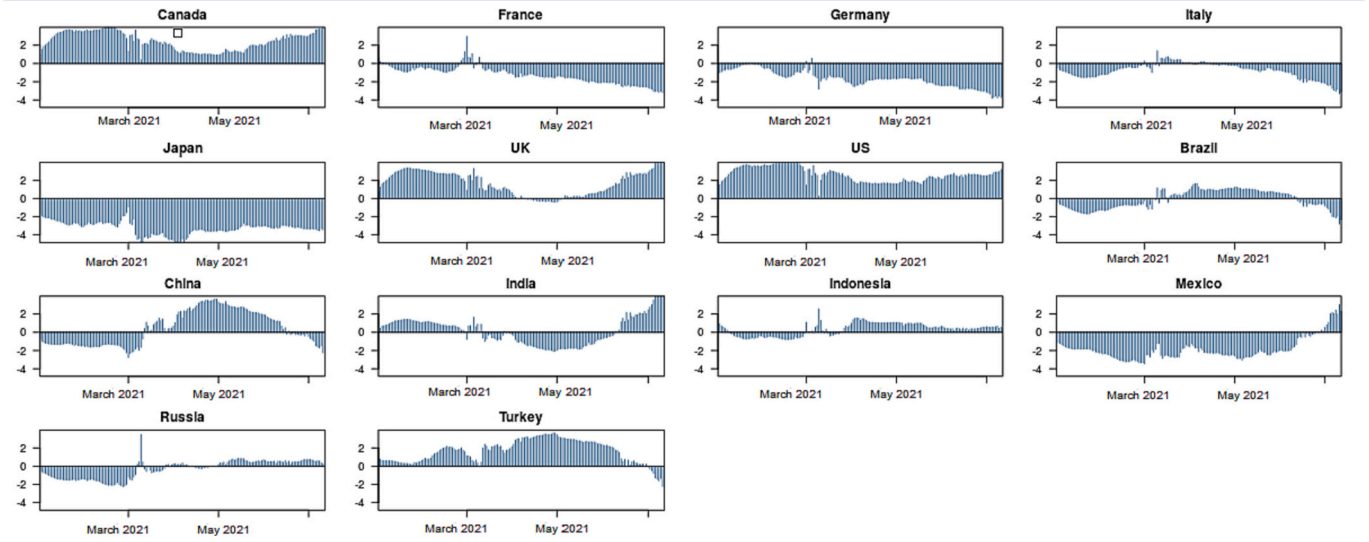

Fig. 3. Net spillover effects of all economies (December 2020 to August 2021).

robust when using the two different indicators for COVID-19 severity.

After controlling for the structural break for each period of COVID-19 severity (Table 8), we still find a difference in the impacts of COVID-19 severity on G-7 and E-7 sovereign bond yields.

Thus, the increase in case numbers had a negative impact on the G-7 countries' bond yields. In contrast, the bond markets in the E-7 economies did increase in yield in response to the rising numbers of COVID-19 cases. Unfortunately, the case of E-7 is not significant although the signs are in line with our previous results. Both results are consistent with our earlier findings.

3.3. Dynamic connectedness across sovereign bond markets: mechanisms analysis

We estimated the dynamic connectedness across the sovereign bond markets by using the Time-varying parameters Vector-Autoregressive model. Fig. 2 illustrates the spillover effects for all 14 economies.

The bond markets exhibit strong connectedness after the public health crisis announcement on 11th March 2021. These findings are also in line with the notion that COVID-19 exhibited unprecedented turmoil and volatility in comparison with the outbreak of other diseases (for example, H1N1, Ebola, SARS 2003 etc.) (Schell, Wang, & Huynh, 2020). Fig. 3 shows the spillover position for each market. A positive value represents a 'net sender' status, while a negative one indicates the opposite position (receiver).

Interestingly, the group of yield shock senders includes Canada, the UK, the US, and Turkey. In contrast, France, Germany, Italy, Mexico, and Russia are passive, that is, they received the shocks from the aforementioned economies. China seemed to send shocks at the beginning of the COVID-19 pandemic (before March 2021); however, there was a reversal after April 2021, when this country began to control the spread of the disease, partly through a severe lockdown. India and Brazil also passed through two distinct phases in terms of shock transmission over the period. This is a clear manifestation of the severity of the pandemic in the corresponding economies.

Tables 9 and 10 summarize the static and dynamic connectedness among the sovereign bond yields. The diagonal of the table represents the country's spillover to itself. The columns show the sending position while the rows show how the sovereign bond receives the level of yield connectedness. One of the most important features is the concentration of spillover level in the G-7 countries. It is obvious that these advanced countries exhibit a stronger interdependence than the E-7 group. The leader of the G-7 is the United States, whereas China plays an active role among E-7 countries. Furthermore, dynamic connectedness has a higher level of spillover than static connectedness. Therefore, the dynamic model perfectly suits the changes in sovereign bond yields.

Table 9
Static connectedness among the sovereign bond yields.

	Canada	France	Germany	Italy	Japan	UK	US	Brazil	China	India	Indonesia	Mexico	Russia	Turkey	FROM
Canada	**26.619**	7.744	4.898	1.876	0.670	7.616	27.120	0.722	7.216	0.698	3.184	8.164	0.458	3.014	73.381
France	5.027	**11.989**	7324	16.991	5.210	2.931	5.392	16.267	9.197	0.872	5.342	0.930	9.359	3.168	88.011
Germany	11.135	14.978	**13.461**	10.616	8.481	8.082	12.086	6.914	6.758	1.055	2.685	1.343	1.506	0.900	86.539
Italy	5.372	3.476	6.696	**19.847**	3.936	1.700	9.036	9.028	15.189	1.209	3.011	1.752	10.532	9.217	80.153
Japan	9.217	4.903	6.657	12.268	**24.162**	3.829	9.357	13.629	6.030	3.256	0.533	0.871	4.150	1.136	75.838
UK	21.991	10.798	5.548	5.119	2.730	**14.827**	20.202	1.737	2.114	0.477	4.528	7.924	0.964	1.042	85.173
US	23.631	7.062	4.570	2.025	1.135	5.704	**27.694**	1.193	8.682	0.742	2.628	8.488	1.556	4.891	72.306
Brazil	6.581	0.159	3.704	3.736	3.965	0.819	7.446	**30.343**	16.141	0.526	3.416	1.623	15.173	6.370	69.657
China	4.195	0.793	2.226	0.374	9.041	0.536	8.415	4.317	**46.237**	1.141	1.999	0.752	9.924	10.049	53.763
India	12.148	3.716	0.484	2.945	2.891	3.616	12.056	8.125	1.242	**21.015**	11.673	9.199	8.382	2.509	78.985
Indonesia	2.843	1.833	3.894	11.458	4.741	0.981	4.840	12.672	14.672	1.429	**10.285**	1.278	20.869	8.204	89.715
Mexico	1.318	0.378	1947	1.885	4.839	0.898	1.395	8.441	12.353	0.297	7.588	**27.618**	16.436	14.607	72.382
Russia	4.789	1.668	4.198	13.930	4.561	1.885	6.515	11.251	10.136	2.935	6.003	0.924	**26.853**	4.353	73.147
Turkey	10.845	2.325	6.405	2.628	2.224	2.067	14.980	12.402	13.616	0.909	0.846	2.557	12.891	**15.307**	84.693
Contribution TO others	119.093	59.836	58.550	85.850	54.423	40.665	138.839	106.698	123.345	15.546	53.436	45.806	112.199	69.458	1.083.744
Contribution including own	145.712	71.825	72.011	105.697	78.586	55.492	166.533	137.040	169.583	36.561	63.720	73.424	139.053	84.765	TCI
Net spillovers	45.712	−28.175	−27.989	5.697	−21.414	−44.508	66.533	37.040	69.583	−63.439	−36.280	−26.576	39.053	−15.235	77.410

Notes: This table demonstrates the results of the yield spillover effects performed with the generalized FEVD (GFEVD) in the static form. Directional return spillovers correspond to the percentage share of error variance in exchange rate n (rows) contributed by shocks to sovereign bond m (columns). Total received spillover for bond yield n is given by its row sums reported in the columns added to the right of the table, both including the sum of 100 and excluding own variance share.

Table 10
Dynamic connectedness among the sovereign bond yields.

	Canada	France	Germany	Italy	Japan	UK	US	Brazil	China	India	Indonesia	Mexico	Russia	Turkey	FROM
Canada	**19.508**	0.688	7.135	1.964	1.126	17.320	19.297	1.751	6.318	12.309	0.574	3.421	1.139	7.451	80.492
France	2.417	**16.966**	6.196	12.866	6.578	2.831	2.536	10.347	3.798	2.107	12.278	3.272	9.084	8.724	83.034
Germany	8.958	14.373	**20.549**	3.160	8.199	11.253	8.839	2.087	4.941	5.795	4.155	2.422	3.676	1.595	79.451
Italy	5.866	7.608	1.925	**17.873**	2.744	2.908	6.908	9.181	10.894	1.605	9.084	3.380	5.816	14.210	82.127
Japan	7.373	11.438	4.978	10.000	**21.979**	4.083	7.117	7.506	2.450	5.133	4.335	2.367	2.700	8.541	78.021
UK	18.942	1.975	6.955	0.835	1.048	**19.463**	18.107	0.798	3.710	13.244	1.577	5.448	3.365	4.533	80.537
US	18.842	0.479	7.036	2.172	0.988	16.066	**19.596**	2.720	7.661	10.991	0.557	2.871	0.687	9.334	80.404
Brazil	4.772	4.590	1.734	6.552	1.884	2.728	5.927	**20.371**	10.771	2.436	11.650	1.781	11.055	13.750	79.629
China	8.488	1.779	6.125	4.327	1.157	6.545	9.943	7.026	**21.228**	4.097	7.696	4.391	4.785	12.414	78.772
India	17.269	1.294	5.511	1.010	1.889	16.446	16.214	0.842	2.622	**18.904**	3.073	7.946	3.456	3.525	81.096
Indonesia	1.272	9.035	1.376	9.259	1.689	2.284	1.288	11.727	7.695	3.691	**18.122**	7.216	14.823	10.522	81.878
Mexico	8.162	3.264	2.357	3.335	1.871	9.343	7.005	2.550	5.661	12.970	10.452	**22.073**	6.633	4.323	77.927
Russia	3.347	6.370	1.346	7.560	1.613	6.457	2.392	10.411	4.854	6.420	14.098	6.717	**23.502**	4.914	76.498
Turkey	9.363	2.848	3.152	8.263	1.717	5.300	11.432	10.848	12.749	2.980	7.174	1.088	4.796	**18.292**	81.708
Contribution TO others	115.069	65.740	55.825	71.304	32.501	103.564	117.004	77.792	84.124	83.779	86.702	52.319	72.015	103.837	1.121.576
Contribution including own	134.577	82.706	76.374	89.177	54.479	123.027	136.600	98.163	105.352	102.683	104.824	74.392	95.517	122.129	TCI
Net spillovers	34.577	−17.294	−23.626	−10.823	−45.521	23.027	36.600	−1.837	5.352	2.683	4.824	−25.608	−4.483	22.129	80.113

Notes: This table demonstrates the results of the yield spillover effects performed with the generalized FEVD (GFEVD) in the dynamic form. Directional return spillovers which correspond to the percentage share of error variance in exchange rate n (rows) contributed by shocks to sovereign bond m (columns). Total received spillover for bond yield n is given by its row sums reported in the columns added to the right of the table, both including the sum of 100 and excluding own variance share.

Table 11
Predictive factors of COVID-19 case and death numbers and daily Disease Equity Market Volatility factor on total connectedness.

Variables Y = Total connectedness	Model (1)	Model (2)	Model (3)	Model (4)
Growth of COVID-19 cases	0.822	1.082*		
	[1.27]	[0.794]		
Growth COVID-19 deaths			1.852*	1.962**
			[1.85]	[2.268]
EMV		0.033***		0.033***
		[3.224]		[3.378]
MSCI World		−16.556**		−16.289**
		[−2.151]		[−2.147]
Gold		−1.156		−1.521
		[−0.081]		[−0.107]
Crude oil		−3.680**		−3.456*
		[−1.985]		[−1.917]
Constant	80.042***	79.338***	79.955***	79.248***
	[465.13]	[279.966]	[448.32]	[283.930]
R-squared (%)	0.50	15.60	2.81	17.82
F-stat	1.61	6.01	3.43	6.51

Notes: The values in parentheses are t-statistics based on robust standard errors. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively. The dependent variable is the total connectedness, which was extracted from the TVP-VAR model. The EMV represents the daily Infectious Disease Equity Market Volatility Tracker (Baker et al., 2020a). MSCI World index, gold and crude oil are in the natural log of returns.

Table 12
Predictive factors of COVID-19 case and death numbers and daily Disease Equity Market Volatility factor on total connectedness using weekly data.

Variables Y = Total connectedness	Model (1)	Model (2)	Model (3)	Model (4)
Growth of COVID-19 cases	2.533	3.067		
	[1.290]	[1.405]		
Growth COVID-19 deaths			3.724	3.530
			[1.424]	[1.614]
EMV		0.046*		0.044**
		[1.939]		[2.066]
MSCI World		−79.093**		−78.076**
		[−2.275]		[−2.352]
Gold		39.571		39.699
		[0.606]		[0.625]
Crude oil		−11.505**		−11.006***
		[−2.675]		[−2.884]
Constant	79.724***	78.686***	79.631***	78.679***
	[176.072]	[96.547]	[182.293]	[108.776]
R-squared (%)	0.02	0.355	0.06	0.381
F-stat	1.67	9.00	2.03	8.54

Notes: The values in parentheses are t-statistics based on robust standard errors. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively. The dependent variable is the total connectedness, which was extracted from the TVP-VAR model. The EMV represents the daily Infectious Disease Equity Market Volatility Tracker (Baker et al., 2020b). MSCI World index, gold and crude oil are in the natural log of returns. The data was average approach in aggregated data from daily to weekly scale. The total number of observations is 33.

Our findings contribute to the literature on the sovereign bond yield during a time of crisis. The study by Antonakakis and Vergos (2013) shed light on the eurozone debt crisis and the Global Financial Crisis (2008–2009). Our results are also consistent with the highly intertwined connection between two groups (G-7 and E-7 economies). In the same vein, Sensoy, Nguyen, Rostom, and Hacihasanoglu (2019) have emphasised the dynamic integration of sovereign bond markets in the European Monetary Union (EMU) markets. We contribute to this literature by looking at a public health crisis, a crisis that is not limited to the Eurozone but that represents a global tragedy.

To examine whether the numbers of COVID-19 confirmed cases and deaths predict total connectedness, we establish a regression with rigorous control variables. A summary of the results is presented in Table 11. We followed the previous studies of Bouri, Saeed, Vo, and Roubaud (2021) using EMV (Equity Market Volatility) as the predictive power for total connectedness. As Baker, Bloom, Davis, and Kost (2019) made the caveat that EMV moves with the VIX, using two indices at the same time could not bring a better interpretation. Therefore, we would keep the EMV to explicitly explain the policy news as the main driver of market volatility. Concomitantly, the objective of this part is to use other determinants which could predict the sovereign bond connectedness. During the evolution of COVID-19, the shake of the equity market, commodity market, and safe-haven could matter. With the existing literature, we would like to control these variables to measure the bond yield connectedness.

Three main inferences can be drawn from Table 11. First, the effect of the growth in the number of COVID-19 cases is weaker (one is a null result, and one is significant at the 10% level) than the effect of the growth in the number of COVID-19 deaths (after controlling rigorous variables, the coefficient is significant at the 5% level). However, EMV is likely to be the strongest predictor of the total connectedness of the 14 economies, since all coefficients are significant at the 1% level. Furthermore, the changes in the total connectedness can be partly explained (15.60% to 17.82% of the variance is accounted for) by the changes in the set of COVID-19 indicators and other control variables, namely the MSCI world index, gold, and crude oil. These findings contribute to the notion that the COVID-19 indicators play a mediating role in the interconnections in financial markets (Lin & Su, 2020).

Both tables (Tables 11 and 12) provide consistent results of predictive power on sovereign bond yield connectedness, except for the COVID-19 cases and deaths. We take this chance to explain the sensitivity of COVID-19 cases and deaths. First, the variation of COVID-19 cases and deaths might be different with the time horizons (for example, the growth of cases and deaths in daily data might be larger than that of weekly data). Therefore, we decided to extend our robustness check for the baseline model (from Table 5) to the weekly and monthly data in the following section. Accordingly, based on results presented in Tables 11 and 12, we come to the conclusion that the daily growth of cases and death could act as the better predictive power on the sovereign bond yield connectedness instead of a weekly one. When it comes to other determinants, our findings are also in line with the existing literature. The Equity Market Volatility, implying the policy news, could shake the interrelationship between the bond yield market (Baker et al., 2019). Concomitantly, Jareño, Martínez-Serna, and Chicharro (2022) and Wang, Wei, Zhang, and Liu (2022) also confirm that the market volatility, market returns, and crude oil return changes, safe-haven (particularly, gold) matter to the government bond. To sum up, this part sheds new light to explain the mechanisms as well as channels of other macroeconomic factors on sovereign bond yield connectedness. (See Table 13.)

3.4. Robustness check with weekly data

When looking at the weekly data, we found that all signs of coefficients are persistent and robust. However, the effects of the number of country cases are null in the G-7 countries. In contrast, we found the marginal effects of case growth in E-7 could predict the changes in sovereign bond yield. We can explain this effect by the timeliness of COVID-19 cases growth could matter. More specifically, the high speed of growing cases in G-7 countries could act as the prediction in the daily data, while E-7 might control the COVID-19 situation better. Therefore, the weekly data might play an important role in emerging markets.

However, when it comes to the monthly data, the effects of all countries (full sample) do not hold. However, each component exhibit the correct signs (G7 with negative signs and E7 with positive signs). These separate signs are significantly different from zero, implying the predictive power of sovereign bond yield. Therefore, doing the robustness check confirm the role of data intervals. Analysis of the shift in capital flight could be done based on the monthly data.

Table 13
COVID-19 Pandemic and Sovereign bonds market after controlling for structural breaks by using aggregated data.

Dependent variable: SBY	Weekly			Monthly data		
	All countries	G-7 countries	E-7 countries	All countries	G-7 countries	E-7 countries
Growth CC	0.075	−0.019	0.345**	0.118	−0.186*	0.638*
	[0.113]	[0.012]	[0.042]	[0.305]	[0.057]	[0.064]
G-7-E-7	3.726	–	–	3.785	–	–
	[3.324]			[3.865]		
INTR	0.094	0.478***	−0.304	0.126	0.478***	−0.279
	[0.257]	[0.001]	[0.293]	[0.292]	[0.003]	[0.411]
EXCHR	−0.029**	0.008**	0.021*	−0.024**	0.011**	0.030*
	[0.026]	[0.010]	[0.052]	[0.029]	[0.010]	[0.062]
SMR	1.907	3.078**	11.108	−11.827	−8.387	5.771
	[3.792]	[0.041]	[4.925]	[14.400]	[11.483]	[24.983]
LNMC	0.013**	−1.650	−0.001**	0.016**	−0.186*	0.004**
	[0.013]	[1.298]	[0.025]	[0.013]	[0.057]	[0.030]
Constant	3.134	24.368	0.000***	2.554	12.742	8.796
	[2.006]	[18.907]	[0.000]	[2.287]	[11.594]	[3.048]
Daily effects	Yes	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes	Yes
Structural break (weekly)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	448	224	224	112	56	56
R squared	0.980	0.969	0.956	0.948	0.978	0.966

Notes: The values in parentheses are *p*-values based on robust standard errors that are clustered by country and day. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. The control for structural break can be done with a dummy variable for three sub-sample groups (before 12th March 2020, from 12th March 2020 to 16th April 2020, from 17th April 2020 to 19th May 2020, after 19th May 2020). The baseline is the period before 12th March 2020. The data has been aggregated into weekly data from the Table 8, which uses the daily data.

4. Conclusion

The COVID-19 pandemic has been the most significant event of the 21st century. The financial markets have not been immune to the pandemic and in fact their dynamics suggest a bleak outlook for the economy. In this context, one of the crucial issues is the *flight to safety* and the role of sovereign bonds as a safe haven for global capital. Historically, the US and the other developed economies, specifically the G-7, have been considered as safe places to shelter investment during a time of crisis. However, the emergence of new players has raised the question of the ability of their sovereign bonds likewise to be a safe haven. In this context, this study has investigated the impact of the COVID-19 pandemic on sovereign bond yields and examined how and whether the level of economic growth of a country influences the sovereign bond yield's response to the growth in the number of COVID-19 cases. The key question is whether E-7 bonds were seen as a good substitute for G-7 sovereign debt early on in the pandemic. To answer these questions, we employed panel approaches to estimation. Our results lead us to conclude that the impact of the growth in COVID-19 case numbers on sovereign bonds was indeed influenced by the country's level of economic development. More precisely, our results also lead us to infer that the G-7 countries, where economic and financial market development is typically higher, exhibit a negative effect of the COVID-19 pandemic on sovereign bond yield. The sovereign bond yields declined as the number of COVID-19 globally confirmed cases increased. Thus, the G-7 sovereign bonds markets are shown to have been seen as safe havens. In contrast, in the E-7 countries, which are, as the name suggests, emerging economies whose level of economic development is typically lower, sovereign bond yields responded positively to the increase in the numbers of COVID-19 global confirmed cases, but this positive effect is not statistically significant. This implies that the sovereign bonds of E-7 economies, despite their rapid growth in the recent past, were not seen as safe havens. This is important inference to draw and relates to our discussion in the introduction section where we discussed the issues around "Original Sin". The global financial structure is hierarchical and the developed markets in general and the US in particular sit at the top. Therefore, whenever there is a crisis global capital rushes to the safe heavens of developed economies' sovereign bond markets, particularly the US sovereign bonds and treasuries which have been the bedrock of the global financial system. The developing economies and their sovereign bonds markets are of course not there yet. This is the reason that despite the fact that sovereign bonds are safer investment classes in developing economies, they are not that attractive, yet in times of crisis, global capital finds refuge in developed markets even if that means a lower rate of return manifested in the lower yields.

To examine the interdependence among the sovereign debt markets further, we have investigated the connectedness and spillover effects among these markets. This analysis led us to conclude that the G-7 and the E-7 both have a strong time-varying connectedness, but it is more pronounced in G-7 economies. This shows that the integration of G-7 markets is greater than the E-7 markets which are intuitive, considering the fact that the G-7 economies and financial markets are more liberalised and integrated into the global financial structure. This higher level of integration is manifested in the strong and time-varying connectedness in the G-7 markets which become more pronounced during the crisis, such as COVID-19. Our results also lead us to conclude on the predictive power of the Infectious Disease Equity Market Volatility. EMV is the strongest predictor of the total connectedness of the 14 economies which manifests that the infectious disease-related volatility of the equity market can have implications for the sovereign bonds markets of the underlying economies. Concomitantly, we shed new light on the predictive power of COVID-19 confirmed case and death numbers, and the Daily Infectious Disease Equity Market Volatility Tracker on the interdependence of these sovereign bond markets.

In conclusion, this paper highlights the heterogeneous effect of the COVID-19 pandemic on sovereign bond yields in G-7 and E-7 countries. This has crucial implications for investors and fiscal authorities interested in the development of their sovereign bond markets. In this study we focused on the Pandemic which was a swift and dynamic phenomenon of unique nature with severe implications, however, in the long term, there are various factors, for instance, economic growth and government debt level. For these long-term factors, there are studies in the literature, yet further research can be done which may have data from several years.

Data availability

Data will be made available on request.

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