Volatility in International Sovereign Bond Markets: The Role of Government Policy Responses to the COVID-19 Pandemic

Abstract

Effective government policies may reduce uncertainty in sovereign bond markets. Can policy responses help to curb bond market volatility during the COVID-19 pandemic? To answer this, we examine data from 31 developed and emerging markets for the coronavirus outbreak in 2020. We demonstrate that government interventions substantially reduce local sovereign bond volatility. The effect is mainly driven by economic support policies; the containment and closure regulations and health system interventions play no major role.

Keywords: COVID-19 pandemic, coronavirus outbreak, government policy responses, containment and closure, economic support, sovereign bonds, government bond market volatility.

JEL codes: G01, G12, G15, G18, H12, H51, I18

1. Introduction

The recent outbreak of COVID-19 triggered unprecedented government policy responses around the world to alleviate the economic and non-economic adverse effects of the disease. These exceptional circumstances spurred numerous studies of the impact of government interventions on global stock markets (e.g., Ashraf 2020a; Baig et al. 2020; Haroon and Rizvi 2020; Phan and Narayan 2020; Zaremba et al. 2020a). However, sovereign bonds, which are more directly affected by government actions and expenditures, have largely escaped academic scrutiny. We seek to rectify this gap by exploring the influence of policy responses to COVID-19 on the volatility of sovereign bonds.

COVID-19 injected large-scale economic uncertainty into financial markets (Baker et al. 2020a,b; Sharif et al. 2020). There is evidence that increased uncertainty along with unstable business conditions is a major source of bond market volatility (Arnold and Vrugt 2010; Asgharian et al. 2015; Bansal and Shaliastovich 2013; Beber and Brandt 2009; Ulrich 2012, 2013a; Viceira 2012), but the risks can be reduced by government interventions (Amengual and Xiu 2018; Kizys et al. 2020). Effective policy responses can lower the uncertainty spurred by COVID-19 (Kizys et al. 2020) and, in turn, bond volatility may decline when economic uncertainty is resolved (Amengual and Xiu 2018). Thus, if government interventions decrease the overall uncertainty and improve business expectations, they should make the fixed-income investments less risky (Viceira

2012), specially that bond markets are highly sensitive to macroeconomic news (Jones, Lamont, and Lumsdaine 1998).

An opposite view, advanced by Pastor and Veronesi (2012), indicates that policy change can actually create further uncertainty surrounding the outcomes of the current and future interventions, which is conducive to higher bond volatility. Volatility can rise in at least four scenarios: a) when fiscal stabilization policies raise uncertainty about future tax pressure (Croce et al. 2012); b) when Knightian uncertainty about changes in future inflation dominates Knightian uncertainty about the economic effects induced by government interventions (Ulrich 2012); c) in periods of heightened Knightian uncertainty about both Ricardian equivalence and the size of the government multiplier (Ulrich 2013b); and d) if government interventions involve public spending decisions, which in turn lead to positive bond term premia through a positive correlation between marginal utility and inflation (Bretscher et al. 2020).

Thus, on the one hand, government interventions might provoke heightened uncertainty and surges in bond volatility, which can impair the market value of sovereign bonds and result in financial losses. In this case, although the intention of the government interventions is to improve health outcomes, and to minimize the economic and social costs of COVID-19, such an intention is not necessarily realized. If, however, the sovereign debt market perceives government interventions as stabilizing, volatility might decrease. Thus, our investigation can help policy makers improve their decision making. In the light of these two sides of the barricade, scrutiny of the actual impact of government interventions on sovereign bond volatility is of paramount importance.

Our research findings can provide market participants with insights into how sovereign debt markets respond to a range of government policies, such as health system interventions, containment and closure regulations, and economic interventions. For instance, our research findings can assist policy makers who seek to design and fine-tune their policies to mitigate the effects of COVID-19, and portfolio managers to prepare better for possible government interventions during future epidemics or later in the current one.

To test these two perspectives regarding the role of government responses (closure, health, and economic support policies (henceforth "stimuli")) on sovereign bond volatility, we examine data from 31 countries during COVID-19 via panel regressions.

We provide evidence that COVID-19 government responses stabilize sovereign bond markets and are instrumental in decreasing volatility. This effect is mainly driven by economic stimuli, such as income support and debt or contract relief.

We contribute to three major fields of research. First, we add to the literature that evaluates the impact of government responses to COVID-19 on financial markets (Ashraf 2020a;

Baig et al. 2020; Haroon 2020; Phan and Narayan 2020; Zaremba et al. 2020a). Whereas earlier papers concentrate solely on equities, we are the first to consider fixed-income securities.

Second, we extend the discussion on the effect of COVID-19 on sovereign bonds. To the best of our knowledge, only He et al. (2020), who scrutinize the shifts in the term structure of U.S. Treasury yields, Arellano et al. (2020) and Sène et al. (2020), who investigate changes in emerging markets' Eurobond yields, and Zaremba et al. (2020b), who examine the effect of the COVID-19 pandemic on the term structure of interest rates, have contributed to this discussion to date.

Third, we contribute to the fast-mounting evidence on the effect COVID-19 on asset volatility. Although numerous papers report on such research focusing on equities (e.g., Albulescu 2020; Corbet et al. 2021; Lyócsa et al. 2020), commodities (e.g., Bakas and Triantafyllou 2020; Corbet et al. 2020; Umar et al 2020), or cryptocurrencies (Conlon and McGee 2020; Corbet et al. 2020; Mnif et al. 2020; Umar and Gubareva 2020), no research focuses on sovereign bonds.

The remainder of the paper is structured as follows. Section 2 presents the data and methodology. Section 3 discusses the empirical findings. Finally, Section 4 concludes the paper.

2. Data and Methodology

We study 31 developed and emerging markets from different global regions (North America, Europe, Asia, Africa, Oceania) covered by Datastream. To assure a consistent empirical approach, volatilities are computed from Datastream 10-Year Government Bond Total Returns indices. The 10-year bonds receive the best international coverage and are typically more liquid than bonds of other maturities, so they are a prime choice in recent large-scale studies on global sovereign bonds (e.g., Baltussen, Swinkels, and van Vliet 2020; Geczy and Samonov 2017; Ilmanen et al. 2019). The list of countries and the statistical properties of index returns is summarized in Table A1 (Online Appendix). The sample period for daily data covers the time during which the pandemic was first spreading and runs from January 1, 2020 through September 12, 2020.

To guarantee comparability across markets, in our baseline approach we closely follow the standard approach taken in asset pricing studies on international sovereign bonds (e.g., Asness et al. 2013; Geczy and Samonov 2017) that express market data in U.S. dollars. Consistent with this, the risk-free asset for factor models is proxied by the U.S. one-month T-bill rate from French (2020).

To gauge day-to-day changes in volatility, we build on Antonakakis and Kizys (2015) and Khalifa, Miao, and Ramchander (2011), who use absolute measures of daily performance to derive volatility measures. Although one of the common approaches is to use absolute values of daily returns (e.g., Khalifa, Miao, and Ramchander 2011), in a cross-sectional study such measures may be influenced by the variation in systematic risks. To extract the country-specific volatility component, which disinherits the influence of systematic risks, we use residuals in absolute value from several factor models (see Zaremba et al. 2020a). Importantly, unlike when studying equities, there is no "gold standard" or single broadly acknowledged cross-sectional asset pricing model for government bonds. Therefore, we form an ad-hoc asset pricing model that comprises a battery of factors identified in the fixed-income literature (Asness et al. 2013; Bektić et al. 2020; de Carvalho et al. 2014; Ejsing et al 2012; Gava et al. 2020; Kang et al. 2019; Luu and Yu 2012; Martens et al. 2019; Zaremba and Czapkiewicz 2017). Specifically, our seven-factor model aims to capture the known multidimensionality of the cross-section of global sovereign bond returns:

$$R_{i,t} = \alpha_i + \beta_i^{MKT} MKT_t^F + \beta_i^{DUR} DUR_t^F + \beta_i^{CRED} CRED_t^F + \beta_i^{SIZE} SIZE_t^F + \beta_i^{MOM} MOM_t^F + \beta_i^{REV} REV_t^F + \beta_i^{CAR} CAR_t^F + \varepsilon_{i,t}, \quad (1)$$

where $R_{i,t}$ is the daily return on sovereign bonds in country *i* on day *t*, α_i is the abnormal return ("alpha"), and $\varepsilon_{i,t}$ denotes the error term. The regression coefficients β_i^{MKT}, β_i^{DUR}, β_i^{CRED}, β_i^{SIZE}, β_i^{MOM}, β_i^{REV}, and β_i^{CAR} measure the exposures to the market risk (MKT^F), duration (DUR^F), credit risk ($CRED^F$), size ($SIZE^F$), momentum (MOM^F), long-term reversal (REV^F), and carry (CAR^F) risk factors, respectively. The market risk factor reflects the excess return on the global long-term government bond market portfolio. The remaining factor returns are derived from cross-sectional data and represent long-short portfolios buying (selling) bond baskets with the highest (lowest) adjusted duration (DUR^F), rating-based credit risk ($CRED^F$), long-term yield change (REV^F), and local yield-based carry (CAR^F) or with the lowest (highest) market value ($SIZE^F$) and short-term yield change (MOM^F). The use of these factors to explain the cross-section of sovereign bond returns receives support in the above-cited literature. Tables A2 and A3 (see Online Appendix) provide details of the factor construction and statistical properties of the factor returns.

To obtain the look-ahead bias-free absolute daily seven-factor model residuals ($|RR_7|$) for day *t*, we proceed in three steps. First, we estimate Equation (1) using data from the previous five years ending on day *t*-1. Second, we use the coefficient estimates and factor realizations from day *t* to obtain the expected daily returns. Third, the residual return is calculated as the difference between the realized day *t* return and the model-implied expected return.

The government policy responses are represented by the Government Responses Index (*GVT*) of Hale et al. (2020), which is available from OxCGRT (2020). This indicator quantifies and aggregates daily data on a broad range of government policies in response to COVID-19. These responses affect different aspects of social and economic life, which encompass containment and closure (school or workplace closing, restrictions on gatherings, etc.), economic responses (income support, debt relief, fiscal measures), and health system interventions (information campaigns, testing policy, or contact tracing).

We evaluate the effect of policy responses on sovereign bond volatility through the following regressions:

$$BVOL_{i,t} = \alpha + \delta_{GVT} GVT_{i,t} + \sum_{c=1}^{C} \delta_c K_{c,i,t} + u_i + v_{i,t}, \quad (2)$$

where $BVOL_{i,t}$ indicates volatility in country i on day t proxied with $|RR_7|$ (or an alternative measure in our robustness checks), $GVT_{i,t}$ is the Government Response Index, and $K_{c,i,t}$ denotes a set of control variables: average adjusted duration and convexity of the index portfolio (*DUR*, *CX*), quantified sovereign rating score (*CRED*), and market value of the index portfolio (*MV*). We also include the VIX volatility index (*VIX*) obtained from FRED (2020) to account for the systematic component of global financial markets (Hilscher and Nosbusch 2010). To disentangle the effects of policy responses from those of the pandemic itself, we also control for the most essential pandemic-related variable influencing stock markets (Ashraf 2020b), namely, the daily change in the number of COVID-19 infections (ΔINF). Nevertheless, to consider cross-sectional variation in mortality rates, we supplement certain specifications with the daily change in the number of deaths (ΔDTH). We also incorporate weekday dummy variables to account for seasonality (Kiymaz and Berument 2003). The composite random disturbance term, $u_i + v_{i,t}$, consists of two components. The first component is the unobserved country-specific effect, u_i, independent and identically distributed over the panels with mean 0 and standard deviation σ_u. This country-specific effect varies across countries, albeit not over time. The second component is the idiosyncratic shock term, $v_{i,t}$, independent and identically distributed with mean 0 and standard deviation σ_v. The unobserved country varies both across countries and over time.

Furthermore, our empirical methodology allows us to discern the role of economic and non-economic (containment and health) interventions. To explore this, Equation (3) scrutinizes different types of policies separately:

$$BVOL_{i,t} = \alpha + \delta_{ECO} ECO_{i,t} + \delta_{CTNT} CTNT_{i,t} + \sum_{c=1}^{C} \delta_c K_{c,i,t} + u_i + v_{i,t}, \qquad (3)$$

where *ECO* and *CTNT* denote the Economic Response and Containment and Health indices, respectively. These are sub-indices of *GVT*, reflecting the components linked with economic stimuli (debt or contract relief, income support, etc.) and the containment and health policies.[1] They are obtained from OxCGRT (2020) and constructed using methodology consistent with *GVT*. Table A4 provides details of the variables, and Table 1 presents their statistical properties.

[Table 1]

Our baseline regressions are estimated by means of the random-effects estimation method. The motivation is at least four-fold: a) random effects differ across markets, whereas fixed effects are constant (Gelman 2005; Kreft and De Leeuw 1998), b) we are interested in the population rather than in unobserved market-specific features *per se* (Gelman 2005; Searle, Casella, and McCulloch 1992), c) our dataset constitutes only a small fraction of the population (Gelman 2005; Green and Tukey 1960), d) the random-effects approach does not require estimation of country-specific intercepts, which would reduce the number of degrees of freedom.

[1] Importantly, unit root tests of Levin et al. (2002) confirm the stationarity of all major explanatory variables in our regressions (2) and (3). The detailed results are available upon request.

Nevertheless, for robustness, we also employ the fixed-effects and pooled OLS estimation methods. In our regressions, informed by Abadie et al. (2017), Imbens and Kolesár (2016), and Petersen (2009), we use standard errors clustered by country, which are robust to heteroscedasticity and within-country autocorrelation. On the one hand, the volatility of the unanticipated Treasury bond return is notoriously persistent (Jones, Lamont, and Lumsdaine 1998). On the other hand, it is conceivable that the second moment of the volatility of the unanticipated Treasury bond return can vary significantly across countries, which is indicative of the presence of heteroscedasticity. Finally, we also consider several extensions to our baseline methodology, which are reported in Section 4.

3. Results

Table 2 reports the results of our panel regressions. Specifications (1)-(4) focus on the overall role of government policies. These results shed light on the stabilizing role of COVID-19 government responses on volatility. This effect is always significant, irrespective of whether we include the growth of COVID-19 cases separately ((1),(2)) or jointly with the death count ((3),(4)), or whether we include the basic ((1),(3)) or an extended ((2),(4)) set of control variables. The estimated partial slope indicates that a 1-point increase in the Government Response index results in a volatility decline of 0.16% to 0.20%, depending on the specification. Summing up, in line with our conjectures, government responses help to reduce risk and stabilize sovereign bond markets.

[Table 2]

Which government policies curb sovereign bond risk? Specifications (5) to (8) cast light on this issue. Whereas the *ECO* coefficients are negative and significant, *CTNT* does not influence volatility: the estimated effects of *CTNT* do not reliably differ from zero. Thus, we find that economic stimuli stabilize sovereign bond markets. However, we find no evidence for a similar effect of containment and closures.

To endorse the validity of our findings, we carry out further robustness checks. First, we replace the random-effects method with the pooled OLS and fixed-effects methods. Second, we employ additional measures of volatility. Concretely, we estimate residuals from two alternative factor models; a one-factor model incorporating only the market risk factor ($|RR_1|$), and a three-factor model including only the three best-established bond factors: market risk, duration, and credit risk ($|RR_3|$). We also use raw absolute returns both in U.S. dollars ($|R_{USD}|$) and local currency ($|R_{LOC}|$). Third, we use one-day lagged policy variables (from day *t*-1) rather than contemporaneous variables (from day *t*). This addresses any look-ahead bias in our study. Fourth, we consider infections in levels instead of daily changes. Fifth, we replace the change in the infection numbers with the change in the death count. Sixth, we estimate the regressions without infections or deaths. Seventh, we exclude the weekday dummy variables. And eighth, we replace the Containment and Health index with a related Stringency index, concentrating solely on containment and closures.

Notably, none of these changes plays a major role in our overall conclusions (see Table 3). In all the robustness checks, the coefficients of GVT and ECO remain negative and significant. Thus, we conclude that economic stimuli are reliable stabilizers of sovereign bond markets.

[Table 3]

4. Conclusions

Our study is the first attempt to investigate the impact of government responses to COVID-19 on the volatility in sovereign bond markets. We document that government policies help to stabilize international sovereign bond markets. This effect is driven primarily by economic stimuli.

Our conclusions have direct policy implications. Policymakers should be aware that their responses to COVID-19 exert a measurable impact on sovereign bond markets. The ensuing volatility decline may ultimately influence issuer perception and debt financing costs. In addition, portfolio managers can make inferences about future volatility based on economic stimuli.

The major limitation of our study is the freshness and narrowness of the sample. Future exploration of the topics discussed in this paper will enable validation of our findings, also with the use of risk measures derived from fixed-income derivative market. It would be valuable evaluate the role of monetary interventions by major central banks. Moreover, further research of the topics in this article could include investigation of the role of COVID-19 and government response on bond pricing, as well as on the determinants of market reactions around the world. Future studies could also discriminate between “good” and “bad” volatilities (Patton and Sheppard 2015) and scrutinize how each volatility component behaves in the aftermath of specific government policy responses to COVID-19.

References

Abadie, A., S. Athey, G.W. Imbens, and J. Wooldridge. 2017. "When should you adjust standard errors for clustering?". NBER Working Paper No. w24004, https://www.nber.org/papers/w24003.

Albulescu, C.T. 2020. "COVID-19 and the United States Financial Markets' Volatility." *Finance Research Letters*, in press.

Amengual, D., and D. Xiu. 2018. "Resolution of Policy Uncertainty and Sudden Declines in Volatility." *Journal of Econometrics* 203(2): 297-315.

Antonakakis, N., and R. Kizys. 2015. "Dynamic Spillovers between Commodity and Currency Markets." *International Review of Financial Analysis* 41: 303-319.

Arellano, C., Y. Bai, and G.P. Mihalache. 2020. "Deadly Debt Crizes: COVID-19 in Emerging Markets." NBER Working Paper No. 27275. Available at https://www.nber.org/papers/w27275.

Arnold, I.J.M., and E.B. Vrugt. 2010. "Treasury Bond Volatility and Uncertainty about Monetary Policy." *Financial Review* 45(3): 707-728.

Asgharian, H., C. Christiansen, and A.J. Hou. 2015. "Effects of Macroeconomic Uncertainty on the Stock and Bond Markets." *Finance Research Letters* 13: 10-16.

Ashraf, B.N. 2020a. "Economic Impact of Government Interventions During the COVID-19 Pandemic: International Evidence from Financial Markets." *Journal of Behavioral and Experimental Finance* 27, 100371.

Ashraf, B.N. 2020b. "Stock Markets' Reaction to COVID-19: Cases or Fatalities?" *Research in International Business and Finance* 54: 101249.

Asness, C.S., T.J. Moskowitz, L.H. Pedersen. 2013. "Value and Momentum Everywhere." *Journal of Finance* 68(3): 929-985

Avery, C., and P. Zemsky. 1998. "Multidimensional Uncertainty and Herd Behavior in Financial Markets." *American Economic Review* 88(4): 724-748.

Baig, A.S., H.A. Butt, O. Haroon, and S.A.R. Rizvi. 2020. "Deaths, Panic, Lockdowns, and US Equity Markets: The Case of COVID-19 Pandemic." *Finance Research Letters*, in press.

Bakas, D., and A. Triantafyllou. 2020. "Commodity Price Volatility and the Economic Uncertainty of Pandemics." *Economics Letters* 193: 109283.

Baker, S.R., et al. 2020a. "The Unprecedented Stock Market Reaction to COVID-19." Review of Asset Pricing Studies, in press.

Baker, S.R., N. Bloom, S.J. Davis, and S.J. Terry. 2020b. "COVID-Induced Economic Uncertainty." NBER Working Paper No. 26983.

Baltussen, G., L. Swinkels, and P. van Vliet. 2019. "Global Factor Premiums." Available at SSRN: https://ssrn.com/abstract=3325720 or http://dx.doi.org/10.2139/ssrn.3325720.

Bansal, R., and I. Shaliastovich. 2013. "A Long-Run Risks Explanation of Predictability Puzzles in Bond and Currency Markets." *Review of Financial Studies* 26(1): 1-33.

Beber, A., and M.W. Brandt. 2009. "Resolving Macroeconomic Uncertainty in Stock and Bond Markets." *Review of Finance* 13(1): 1-45.

Bektić, D., B. Hachenberg, and D. Schiereck. 2020. "Factor-Based Investing in Government Bond Markets: A Survey of the Current State of Research." *Journal of Asset Management* 21: 94-105.

Bretscher, L., A. Hsu, and A. Tamoni. 2020. "Fiscal Policy Driven Bond Risk Premia." *Journal of Financial Economics* 138(1): 53-73.

Conlon, T., and R. McGee. 2020. "Safe Haven or Risky Hazard? Bitcoin during the Covid-19 Bear Market." *Finance Research Letters* 35: 101607.

Corbet, S., C. Larkin, and B. Lucey. 2020. "The Contagion Effects of the COVID-19 Pandemic: Evidence from Gold and Cryptocurrencies." *Finance Research Letters* 35: 101554.

Corbet, S., Y.G. Hou, Y. Hu, L. Oxley, and D. Xu. 2021. "Pandemic-Related Financial Market Volatility Spillovers: Evidence from the Chinese COVID-19 Epicentre." *International Review of Economics & Finance* 71: 55-81.

Croce, M.M., H. Kung, T.T. Nguyen, and L. Schmid. 2012. "Fiscal Policies and Asset Prices." *The Review of Financial Studies*, 25(9): 2635-2672.

Daehler, T., J. Aizenman, and Y. Jinjarak. 2020. "Emerging Markets Sovereign Spreads and Country-Specific Fundamentals During Covid-19." NBER Working Paper No. w27903, Available at SSRN: https://ssrn.com/abstract=3705114.

de Carvalho, R.L., P. Dugnolle, X. Lu, and P. Moulin. 2014. "Low-Risk Anomalies in Global Fixed Income: Evidence from Major Broad Markets." *Journal of Fixed Income* 23(4): 51-70.

Ejsing, J., M. Grothe, and O. Grothe. 2012. "Liquidity and Credit Risk Premia in Government Bond Yields." European Central Bank Working Paper No. 1440.

FRED. 2020. Chicago Board Options Exchange, CBOE Volatility Index: VIX [VIXCLS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/VIXCLS, October 11, 2020.

French, K.R. 2020. U.S. Research Returns Data. Data Library. Retrieved from http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html [accessed on 1 October 2020].

Gava, J., W. Lefebvre, and J. Turc. 2020. "Beyond Carry and Momentum in Government Bonds." *Journal of Fixed Income* 29(4): 48-74.

Geczy, C., and M. Samonov. 2017. "Two Centuries of Multi-Asset Momentum (Equities, Bonds, Currencies, Commodities, Sectors and Stocks)." Available at SSRN: https://ssrn.com/abstract=2607730 or http://dx.doi.org/10.2139/ssrn.2607730.

Gelman, A. 2005. "Analysis of Variance: Why It Is More Important than Ever." *Annals of Statistics* 33(1): 1-31.

Green, B.F., and J.W. Tukey. 1960. "Complex Analyses of variance: General Problems." *Psychometrika* 25: 127-152.

Hale, T., et al. 2020. "Variation in Government Responses to COVID-19." BSG Working Paper Series, BSG-WP-2020/032, Version 7.0. Available at https://www.bsg.ox.ac.uk/sites/default/files/2020-09/BSG-WP-2020-032-v7.0.pdf.

Haroon, O., and S.A.R. Rizvi. 2020. "Flatten the Curve and Stock Market Liquidity – An Inquiry into Emerging Economies." *Emerging Markets Finance and Trade* 56(10: 2151-2161.

Hilscher, J., and Y. Nosbusch. 2010. "Determinants of Sovereign Risk: Macroeconomic Fundamentals and the Pricing of Sovereign Debt." *Review of Finance* 14(2): 235-262.

Ilmanen, A.S., R. Ronen, T.J. Moskowitz, A.K. Thapar, and F. Wang. 2019. "How Do Factor Premia Vary Over Time? A Century of Evidence." Available at SSRN: https://ssrn.com/abstract=3400998 or http://dx.doi.org/10.2139/ssrn.3400998.

Imbens, G.W., and M. Kolesár. 2016. "Robust Standard Errors in Small Samples: Some Practical Advice." *The Review of Economics and Statistics* 98(4): 701-712.

Jones, C.M., O. Lamont, and R.L. Lumsdaine. 1998. "Macroeconomic News and Bond Market Volatility." *Journal of Financial Economics* 47(3): 315-337.

Kang, J., K. So., and T. Tziortziotis. 2019. "Embedded Betas and Better Bets: Factor Investing in Emerging Market Bonds." *Journal of Investment Management* 17(3).

Khalifa, A.A.A., H. Miao, and S. Ramchander. 2011. "Return Distributions and Volatility Forecasting in Metal Futures Markets: Evidence from Gold, Silver, and Copper." *Journal of Futures Markets* 31: 55-80.

Kiymaz, H., and H. Berument. 2003. "The Day of the Week Effect on Stock Market Volatility and Volume: International Evidence." *Review of Financial Economics* 12(4): 364-380.

Kizys, R., P. Tzouvanas, and M. Donadelli. 2020. "From COVID-19 Herd Immunity to Investor Herding in International Stock Markets: The Role of Government and Regulatory Restrictions." *International Review of Financial Analysis* 74: 101663. .

Koijen, R.S.J., T.J. Moskowitz, L.H. Pedersen, E.B. Vrugt. 2018. "Carry." *Journal of Financial Economics* 127(2): 197-224.

Kreft, I.G., and J. De Leeuw. 1998. *Introducing Multilevel Modeling*. Sage.

Levin, A., C.-F. Lin, and C.-S. J. Chu. 2002. "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties." *Journal of Econometrics* 108: 1–24.

Luu B.V., P. Yu. 2012. "Momentum in Government-Bond Markets." *Journal of Fixed Income* 22(2): 27-79

Lyócsa, Š., E. Baumöhl, T. Výrost, and P. Molnár. 2020. "Fear of the Coronavirus and the Stock Markets." *Finance Research Letters* 36: 101735.

Martens, M., P. Beekhuizen, J. Duyvesteyn, and C. Zomerdijk. 2019. "Carry Investing on the Yield Curve." *Financial Analysts Journal* 75(4): 51-63.

Mnif, E., A. Jarboui, and K. Mouakhar. 2020. "How the Cryptocurrency Market has Performed during COVID 19? A Multifractal Analysis." *Finance Research Letters* 36: 101647.

OxCGRT. 2020. The Oxford COVID-19 Government Response Tracker. Blavatnik School of Government. University of Oxford. Retrieved from https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker [accessed 1 October 2020].

Pastor, L., and P. Veronesi, P. 2012. "Uncertainty about Government Policy and Stock Prices." *Journal of Finance* 67(4): 1219-1264.

Patton, A.J., and K. Sheppard. 2015. "Good Volatility, Bad Volatility: Signed Jumps and The Persistence of Volatility." *The Review of Economics and Statistics* 97(3): 683-697.

Petersen, M.A. 2009. "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches." *The Review of Financial Studies* 22(1): 435-480.

Phan, D.H.B., and P.K. Narayan. 2020. "Country Responses and the Reaction of the Stock Market to COVID-19 – a Preliminary Exposition." *Emerging Markets Finance and Trade* 56(10): 2138-2150.

Searle, S.R., G. Casella, and C.E. McCulloch. 1992. *Variance Components.* Wiley, Hoboken.

Sène, B., M.L. Mbengue, and M.M. Allaya. 2020. "Overshooting of Sovereign Emerging Eurobond Yields in the Context of COVID-19." *Finance Research Letters*, in press.

Sharif, A., C. Aloui, and L. Yarovaya. 2020. "COVID-19 Pandemic, Oil Prices, Stock Market, Geopolitical Risk and Policy Uncertainty Nexus in the US Economy: Fresh Evidence from the Wavelet-Based Approach." *International Review of Financial Analysis* 70: 101496.

Ulrich, M. 2012. "Economic Policy Uncertainty & Asset Price Volatility." Available at SSRN: https://ssrn.com/abstract=1566909 or http://dx.doi.org/10.2139/ssrn.1566909.

Ulrich, M. 2013a. "Inflation Ambiguity and the Term Structure of U.S. Government Bonds." *Journal of Monetary Economics* 60(2): 295-309.

Ulrich, M. 2013b. "How Does the Bond Market Perceive Government Interventions?". Columbia Business School Research Paper No. 12/42, Available at SSRN: https://ssrn.com/abstract=1566932.

Umar, Z., and M. Gubareva. 2020. "A Time-Frequency Analysis of the Impact of the Covid-19 Induced Panic on the Volatility of Currency and Cryptocurrency Markets." *Journal of Behavioral and Experimental Finance* 28: 100404.

Umar, Z., F. Jareño, and A.M. Escribano. 2020. "Dynamic Return and Volatility Connectedness for Dominant Agricultural Commodity Markets During the COVID-19 Pandemic Era." Working paper available at https://doi.org/10.21203/rs.3.rs-75766/v1.

Viceira, L.M. 2012. "Bond Risk, Bond Return Volatility, and the Term Structure of Interest Rates." *International Journal of Forecasting* 28(1): 97-117.

Zaremba, A., and A. Czapkiewicz. 2017. "The Cross Section of International Government Bond Returns." *Economic Modelling* 66: 171-183.

Zaremba, A.., R. Kizys, D.Y. Aharon, and E. Demir. 2020a. "Infected Markets: Novel Coronavirus, Government Interventions, and Stock Return Volatility around the Globe." *Finance Research Letters* 35: 101597.

Zaremba, A., R. Kizys, D.Y. Aharon, and Z. Umar. 2020b. "Term Spreads and the COVID-19 Pandemic: Evidence from International Sovereign Bond Markets." Available at SSRN: https://ssrn.com/abstract=3727882 or http://dx.doi.org/10.2139/ssrn.3727882.

Zhinguo, H., S. Nagel, and Z. Song. 2020. "Treasury Inconvenience Yields during the COVID-19 Crisis." NBER Working Paper No. 27416. Available at https://www.nber.org/papers/w27416.

Table 1. *Statistical Properties of the Key Variables*

The table reports the statistical properties of the key variables used in the study: Government Response Index (*GVT*), Containment and Health Index (*CTNT*), Stringency Index (*STG*), Economic Support Index (*ECON*), number of COVID-19 infections (*INF*) (in thousands), number of COVID-19 deaths (*DTH*) (in thousands), absolute daily residual returns from different models: one-factor model ($|RR_1|$), three-factor model ($|RR3_3|$), and seven-factor model (($|RR_7|$), absolute daily returns in U.S. dollars and local currencies ($|R_{USD}|$, $|R_{LOC}|$), bond duration (*DUR*), sovereign rating (*CRED*), convexity (*CX*), the market value of a bond index portfolio (*MV*) in U.S. dollars, and VIX volatility index (*VIX*). *INF* and *DTH* are reported in thousands and $|RR_7|$, $|RR_3|$, $|RR_1|$, $|R_{USD}|$, $|R_{LOC}|$ are presented in percentage terms. The study period is from January 1, 2020 through September 12, 2020.

	Average	Standard deviation	Skewness	Kurtosis	Minimum	First quartile	Median	Third quartile	Maximum
GVT	48.638	11.488	0.582	1.766	28.678	41.233	47.989	55.057	74.422
CTNT	49.110	13.088	0.541	2.052	25.162	41.209	48.455	55.980	79.407
STG	47.052	14.324	0.573	3.031	21.327	37.706	47.245	55.855	78.288
ECON	45.790	18.582	-0.408	1.855	0.000	37.775	49.451	60.268	74.313
INF	129.174	353.316	4.760	24.198	0.766	8.809	25.075	88.573	1860.691
DTH	7.002	14.555	4.015	18.398	0.012	0.256	0.937	5.096	73.963
$\|RR_7\|$	0.358	0.342	173.034	386.734	0.016	0.133	0.260	0.468	1.488
$\|RR_3\|$	0.363	0.350	168.179	349.732	0.017	0.134	0.258	0.477	1.497
$\|RR_1\|$	0.409	0.415	191.990	469.676	0.016	0.148	0.282	0.523	1.837
$\|R_{USD}\|$	0.586	0.455	142.502	320.678	0.036	0.292	0.499	0.747	1.986
$\|R_{LOC}\|$	0.323	0.290	154.989	390.071	0.011	0.133	0.258	0.423	1.293
DUR	8.545	1.149	-0.747	-0.250	5.852	7.862	8.828	9.391	10.179
CRED	4.624	3.724	0.723	-0.763	1.000	1.000	3.333	8.000	13.000
CX	81.184	21.485	-0.566	-0.710	40.037	67.932	86.827	96.748	111.952
MV	14.048	14.937	0.000	0.000	1.764	5.033	9.232	15.472	67.086
VIX	30.502	14.163	1.301	4.932	12.100	22.280	27.980	35.120	82.690

Table 2. *Policy Responses and Bond Market Volatility*

The table reports the results of the panel data regressions. The dependent variable is the absolute daily residual from the seven-factor model ($|RR_7|$). The independent variables are the Government Response Index (*GVT*), Economic Support Index (*ECON*), Containment and Health Index (*CTNT*), change in the number of COVID-19 infections (Δ*INF*), change in the number of COVID-19 deaths (*ΔDTH*), bond duration (*DUR*), sovereign rating (*CRED*), convexity (*CX*), the market value of a bond index portfolio (*MV*) in U.S. dollars, VIX volatility index (*VIX*), and weekday dummy variables. *#Obs* denotes the number of observations and R^2 represents an adjusted coefficient of determination. The regressions are run using random-effects models. Coefficient standard errors (in parentheses) are robust to autocorrelation and heteroscedasticity. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. All the coefficients are multiplied by 100, except the coefficients for *ΔINF* and *ΔDTH* which are multiplied by 100,000, and the coefficients for *MV* which are multiplied by 100,000,000. The study period is from January 1, 2020 through September 12, 2020.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GVT	-0.196***	-0.169***	-0.187***	-0.161***				
	(0.038)	*(0.038)*	*(0.038)*	*(0.038)*				
ECO					-0.102**	-0.070*	-0.104**	-0.073**
					(0.043)	*(0.037)*	*(0.042)*	*(0.036)*
CNTN					-0.078	-0.090*	-0.064	-0.077
					(0.052)	*(0.051)*	*(0.051)*	*(0.050)*
DUR	-1.000	54.600**	-0.965	54.900**	-0.903	51.900**	-0.864	52.000*
	(1.690)	*(26.700)*	*(1.690)*	*(27.000)*	*(1.710)*	*(26.300)*	*(1.700)*	*(26.600)*
CRED	2.510***	1.200**	2.490***	1.180**	2.470***	1.240**	2.440***	1.230**
	(0.869)	*(0.575)*	*(0.861)*	*(0.571)*	*(0.844)*	*(0.573)*	*(0.833)*	*(0.567)*
VIX	1.280***	1.260***	1.280***	1.270***	1.240***	1.240***	1.240***	1.240***
	(0.162)	*(0.157)*	*(0.162)*	*(0.157)*	*(0.150)*	*(0.151)*	*(0.150)*	*(0.150)*
ΔINF	0.010***		0.096*	0.073	0.004		0.093*	0.073
	(0.000)		*(0.058)*	*(0.048)*	*(0.046)*		*(0.057)*	*(0.048)*
CX		-3.140**		-3.150**		-2.980**		-2.980**
		(1.440)		*(1.460)*		*(1.420)*		*(1.440)*
MV		-0.229***		-0.219***		-0.217**		-0.204**
		(0.000)		*(0.000)*		*(0.000)*		*(0.000)*
ΔDTH			-5.400**	-5.110*			-5.880***	-5.450**
			(2.250)	*(2.690)*			*(2.170)*	*(2.670)*
Weekday dummies	YES	YES	YES	YES	YES	YES	YES	YES
# Obs.	5,673	5,673	5,673	5,673	5,673	5,673	5,673	5,673
R^2	0.182	0.209	0.183	0.210	0.185	0.208	0.187	0.208

Table 3. *Robustness Checks*

The table reports the results of the regression specifications (5) and (8) in Table 3 with additional modifications to the baseline methodology. By default in the standard approach, the independent variable is the absolute daily residual from the seven-factor model ($|RR_7|$), the independent variables are the Government Response Index (*GVT*), Economic Support Index (*ECON*), Containment and Health Index (*CTNT*), change in the number of COVID-19 infections (ΔINF), change in the number of COVID-19 deaths (ΔDTH), bond duration (*DUR*), sovereign rating (*CRED*), convexity (*CX*), the market value of a bond index portfolio (*MV*) in U.S. dollars, VIX volatility index (*VIX*), and weekday dummy variables, and the regressions are run using random-effects models. The reported values are coefficients on *GVT* and *ECON* multiplied by 100. The modifications to the baseline methodology reported here include: using pooled (1) and fixed-effects (2) regression models instead of the random-effects model; replacing the dependent variable $|RR_7|$ with alternative volatility measures: absolute residual from the one-factor model ($/RR_1/$), absolute residual from the three-factor model ($/RR3_3/$), absolute daily returns in U.S. dollars ($/R_{USD}/$) and local currencies ($/R_{LOC}/$) ((3)-(6)); replacing contemporaneous policy variables with one-day lagged policy variables (7), replacing changes in infection numbers with changes in the death count (8), including infections and deaths numbers ((9), (10)); excluding changes in infection and death counts from the model (11); excluding weekday dummy variables (12), and replacing the *CTNT* with the Stringency Index (*STG*) (13). Coefficient standard errors (in parentheses) are robust to autocorrelation and heteroscedasticity. The asterisks *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The study period is from January 1, 2020 through September 12, 2020.

No.	Robustness check	GVT	ECO
(1)	Pooled regression model	-0.215***	-0.206***
		(0.027)	*(0.033)*
(2)	Fixed-effects regression model	-0.156***	-0.080**
		(0.038)	*(0.038)*
(3)	Volatility based on residuals from the one-factor model	-0.197***	-0.170**
		(0.044)	*(0.068)*
(4)	Volatility based on residuals from the three-factor model	-0.162***	-0.091**
		(0.048)	*(0.040)*
(5)	Volatility based on raw USD returns	-0.368***	-0.187***
		(0.044)	*(0.063)*
(6)	Volatility based on raw local returns	-0.312***	-0.155***
		(0.042)	*(0.052)*
(7)	Lagged policy variables	-0.177***	-0.090*
		(0.041)	*(0.046)*
(8)	Change in death count only included	-0.184***	-0.104**
		(0.038)	*(0.043)*
(9)	Infections levels included	-0.169***	-0.070*
		(0.038)	*(0.037)*
(10)	Death levels included	-0.173***	-0.070*
		(0.039)	*(0.037)*
(11)	Changes in number of infections and deaths excluded	-0.194***	-0.102**
		(0.038)	*(0.043)*
(12)	Weekday dummy variables excluded	-0.161***	-0.073**
		(0.038)	*(0.036)*
(13)	Stringency Index included	-0.161***	-0.106**
		(0.038)	*(0.046)*