Uncertainty Related to Infectious Diseases and Forecastability of the Realised Volatility of US Treasury Securities

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Abstract

This paper aims to examine the predictive power of the daily newspaper-based index uncertainty related to infectious diseases (EMVID) for the US Treasury securities' realised volatility (RV) using the heterogonous autoregressive volatility (HAV-RV) model. In our out-of-sample forecast, we find strong significant evidence on the role of the EMVID index in forecasting the volatility of the US Treasury securities in the short-, medium-, and long-run horizons except for the US 2-Year Treasury-Note (T-Note) Futures. Assessing the EMVID index role during the COVID-19 episode, we find that even in this short period the index role in predicting the US Treasury securities is highly significant. These findings have important implications for portfolio managers and investors in times of unprecedented levels of uncertainty resulting from epidemic and pandemic diseases.

JEL Codes: C22; D8; G12

Keywords: Uncertainty; Infectious Diseases; COVID-19; US Treasury securities; Realized Volatility; Forecasting

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1. Introduction

Although the global financial market has become more integrated, the economic gains from holding a portfolio of Treasury securities of the United State (US) as traditional less risky "safe haven" is well-recognised (see Bai & Perron, 2003, Hartmann et al., 2004, Baur & McDermott, 2016, Kopyl & Lee, 2016, Gupta et al., 2021, Kinateder et al., 2021), which state that portfolio managers and investors are often attracted to this asset class because of its ability to offer portfolio diversification and hedging benefits during periods of negative market shock, turmoil in traditional financial markets and economic uncertainty. The US Treasury securities are also considered as "safe-haven" by Kopyl & Lee, (2016) because of their significant lack of default risk triggered by the fact that the US government has massive revenue streams that are approximately over 20 percent of the global output. Cheema & Szulczuk, (2020) argue that the US Treasury security market remains one of the largest risk-free and most liquid financial market in the global economy.

Unsurprisingly, an accurate forecast of the volatility of the US Treasury securities is of tremendous interest to portfolio managers and investors in the pricing of the US Treasury securities and in designing hedging strategies against portfolio risks exposure. These securities have also received high attention in academia, previous financial literature has attempted to predict the future path of the US Treasury securities based on various factors (for example see Hoti et al., 2009, Çepni et al., 2019, Çepni et al., 2020). Recently, the COVID-19 outbreak has resulted in unprecedented levels of uncertainties over our economy, employment[1], finances and of course over our mental and physical health (Alonzi et al., 2020, Jackson et al., 2020). However, we lack empirical evidence on the predictive power of the daily infectious diseases-related uncertainty for the US Treasury securities' realized volatility (RV).[2] As highlighted recently by Gupta et al., (2021), yields of US Treasuries tend to be negatively impacted by uncertainty associated with the outbreak of COVID-

[1] In March 2020, the US experienced a job loss of approximately 3.28 million, which is the highest record ever.

[2] When thinking about volatility we need to consider the risks and opportunities or rewards aspects. More often than not, we think of volatility in term of assets allocation, assets pricing and risks management and overlook its opportunities aspect that may generate returns. However, we need volatility to generate returns. Volatility can also be considered in terms of the market environment. That is, what it tells us about the market environment and how much uncertainty is there in the market we are looking at.

19, i.e., the associated increase in bond returns is likely to enhance volatility due to higher trading.

Given the above, the objective of this paper is to examine for the first time the predictive power of the daily newspaper-based index uncertainty related to infectious diseases (EMVID) of various types (such as MERS, SARS, Ebola, H5N1, H1N1, and most importantly the Coronavirus) for the following US Treasury securities; the US 2-Year Treasury-Note (T-Note), the US 5-Year T-Note, and the US 10-Year T-Note Futures as well as the US 30-Year Treasury-Bond (T-Bond) Futures RV over the short-, medium- and the long-run horizon ($h = 1, h = 2$ and $h = 22$). As further analysis, we also examine the influence of the EMVID index for the Canadian 10-Year T-Notes Futures and the Eurodollar[3] Futures CME RV.

In quantifying the economic uncertainty associated with infectious diseases, we use the newspaper-based index of Baker et al., (2020). The index tracks daily equity-market volatility (EMV), especially in the Chicago Board Options Exchange (CBOE) Volatility Index (VIX). This index is advantageous as it satisfies more time-series data features, has a time lag, is forward-looking, and it fits for real-time COVID-19 analysis. Most importantly, its frequency is daily, thus, intraday data contains accurate and depth information that may lead to more precise estimates and forecasts for daily volatility as advocated by Bonato et al., (2021).

Taking into account the latter, we contribute to research on the US Treasury securities by forecasting their realised volatility computed from 5-minute-interval intraday data, we adopt the modified version of the heterogeneous autoregressive (HAR) model introduced by Corsi, (2009). In particular, we extend the benchmark HAR-RV model by adding the EMVID index and examine its ability to predict the future path of the US Treasury securities from 2nd September 2011 to 20th February 2021. This data period covers various market phases of our economy and the recent COVID-19 pandemic that led to tremendous global economic uncertainties.

According to Flavin et al., (2014), the longer-dated bonds are traditional “safe haven” assets because they have the ability to offer fund managers and investors portfolio diversification and hedging benefits during periods of economic downturns. Therefore,

[3] The Eurodollar is the term that refers to any US dollar held outside the United States banking system.

we expect our results to show that the daily newspaper-based index uncertainty related to infectious diseases plays a role in explaining the US Treasury securities in the long-run.

The rest of our paper is organised as follows: Section 2 presents the data and methodology; Section 3 depicts the results; Section 4 presents the conclusion

2. Data and Methodology

2.1. Data

Data on the US Treasury securities' realised volatility (RV) is directly sourced at the University of Chicago Booth School of Business Risk Lab where it is maintained by Professor Dacheng Xiu. This data can be publicly accessed at https://dachxiu.chicagobooth.edu/#risklab. Trades are collected up to the highest frequency available and cleaned using the prevalent national best bid and offer (NBBO) that is available every second. The RV estimation procedure follows (Xiu, 2010) and is determined using quasi-maximum likelihood estimation of volatility (QMLE) based on moving average models MA(q), using non-zero returns of transaction prices sampled up to its available frequency for days with at least 12 observations. The Akaike Information Criterion (AIC) is employed in choosing the best MA(q). For our analysis, we used the 5-minutes RV estimates.

Data on daily infectious diseases-related uncertainty (EMVID) is developed by Baker et al., (2020). They contract it using a newspaper-based infectious disease equity market volatility tracker from January 1985. This data is publicly available for download from http://policyuncertainty.com/infectious_EMV.html. In constructing the EMVID, the authors specify four terms, E: economic, economy, financial; M: "stock market", equity, equities, "Standard and Poor"; V: volatility, volatile, uncertain, uncertainty, risky; ID: epidemic, pandemic, virus, flu, diseases, coronavirus, MERS, sars, Imola, H5N1 and H1N1. Secondly, daily counts of newspaper articles that contain at least one term in each of E.M.V and ID across approximately 3000 US newspapers. Furthermore, the raw EMVID counts are scaled by the counts of all articles on the same day. Multiplicatively Baker et al., (2020) rescale the resulting series to match the level of the VIX through the overall EMV index and scale the EMVID index articles to total

EMV articles. Our data in both series range from the 02nd of September 2011 to the 20th of February 2021. This is based on data availability and the earliest possible date from our estimation. The data range covers the tremendous economic uncertainty due to COVID-19 and other markets event such as the global financial crisis. The descriptive statistics and plots are presented in the appendix, Table A1 and Figure A1, respectively.

2.2. Methodology: Heterogeneous Autoregressive Realised Variance (HAR-RV) Model

In achieving the purpose of this paper, we employ the HAR-RV model of Corsi, (2009) for the out-of-sample predictability analysis. As an additive cascade model of different volatility component realised in different time horizon, the HAR-RV model can reproduce the main empirical features observed in financial data, long memory, fat tails and self-similarity, while remaining parsimonious and easy to regress (Gkillas et al., 2020). The benchmark HAR-RV model:

$$RV_{t+h} = \beta_0 + \beta_d RV_t + \beta_w RV_{w,t} + \beta_m RV_{m,t} + \varepsilon_{t+h} \quad (1)$$

The h index represents h-days ahead realised volatility, where h = 1, 5, and 22. $RV_{w,t}$ and $RV_{m,t}$, denotes the average RV from day t-6 today t-1 and day t-22 today t-6, respectively. Adding the $EMVID$ index to the benchmark HAR-RV model yields the extended HAR-RV model:

$$RV_{t+h} = \beta_0 + \beta_d RV_t + \beta_w RV_{w,t} + \beta_m RV_{m,t} + \theta EMVID_t + \varepsilon_{t+h} \quad (2)$$

3. Empirical Results

The primary objective of this paper is to examine the ability of the EMVID index in predicting the future path of the US Treasury securities' RV (the US 2-,5- and 10-Year T-Note and the US 30-Year T-Bond Futures) from 02nd September 2011 to 20th February 2021. For analysis purposes, we incorporate the Canadian 10-Year T-Note and the Eurodollar Futures CME RV. As advocated by Bouri et al., (2020), the definitive test for any predictive model is in its out-of-sample performance. We study the out-of-sample predictability of our International Bonds by considering a recursive estimation approach over the period under investigation. Firstly, we start by diagnosing the breakpoints of the HAR-RV model using the multiple structural break test by Bai & Perron, (2003). The following breaks were determined; 2nd July 2013, 9th May 2013, 11th June 2013 and 28th June 2012 for the US 5-,2-, and 10-Year T-Notes and the US 30-Year T-Bond Futures, respectively. These are our earliest breakpoint across the three forecasting horizons. Our recursive estimation starts from these points onward, we then compare the root mean squared forecast errors (RMSFEs) for the benchmark HAR-RV model and the extended HAR-RV model that include the EMVID index under $h = 1, h = 5 \ \ and \ h = 22$. For forecasting accuracy between the benchmark and extended HAR-RV model, we conduct the MSE-F test of McCracken, (2007)

Next, we present the out-of-sample RMSFEs for both the benchmark and extended HAR-RV models in Table 1. Most importantly, our main focusing is on forecasting, therefore, lower values of the RMSFEs in the latter models indicate a better performing model. The out-of-sample forecasting gains are computed using the following formula:

$$FG \ = \ \left(\frac{RMSFE_0}{RMSFE_1} - 1\right) * 100 \qquad (3)$$

Where $RMSFE_0$ and $RMSFE_1$ are the $RMSFEs$ of the benchmark and extended HAR-RV models, respectively. In general, positive or negative FGs indicate a gain or loss in percentages, respectively. In terms of the $RMSFEs$ metrics related to the forecasting accuracy of the US Treasury securities, our out-of-sample results (Table 1) indicate that considering the information contained in the daily newspaper-based index uncertainty related to infectious diseases, an econometrician can acquire 3.32 and 0.04 percent forecasting gains in the US 5-Year T-Note Futures in the $h = 1$ and $h = 5$ respective time horizons. In the US 10-Year T-Note, an econometrician can acquire 0.02 and 0.10 percent forecasting gains in the $h = 1$ and $h = 22$ time horizons, respectively. It is evident that across all the time horizons in the US 30-Year T-Bond Futures, an econometrician can acquire 0.24, 0.016 and 0.17 percent forecasting again[4] ($h = 1, h = 5$ and $h = 22$, respectively) while becoming indifferent in the forecasting gain/ loss of the US 2-Year T-Note Futures[5].

According to the MSE-F statistics, the results of the US 30-Year T-Bond (MSE-F statistics: 8.9517, 5.7317 and 6.26 for $h = 1, h = 5$ and $h = 22$, respectively) are

[4] An econometrician can acquire statistically significant forecasting gains (1.90, 1.18 and 4.06 in the h=1, h=5 and h= 22 horizons, respectively) from the Eurodollar Futures.
[5] This indifference in forecasting gain/loss in the Canadian 10-Year T-Note Futures in evidence.

statistically significant at all levels of significance while the results of the US 5-Year T-Note are only significant at the $h = 1$ and $h = 5$ time horizons with MSE-F statistics of 123.4133 and 1.5387, respectively. The results of the US 10-Year T-Note are statistically significant at the $h = 1$ and $h = 22$ horizons with MSE-F statistic values of 0.7944 and 3.7104, respectively. In contrast, the results of the US 2-Year T-Note Futures are insignificant at all levels. The MSE-F critical[6] values are obtained from Table 4 of (McCracken, 2007). These results indicate that daily infectious diseases-related uncertainty has or rather contain important information for forecasting the clear path of the US Treasury securities.

To cover for the COVID-19 episode, we conduct our analysis where the in-sample estimation is till the end of December 2019 and the out-of-sample forecast starts from the first date of January 2020 till the end date of our data. In our case, the breaking point is on 03rd January 2021. Most importantly, this is the time where the entire globe was starting to experience the pandemic and a panic reacting from economic agent perpetrated the impact of the virus on our economies (Gopinath, 2020). This was pure because the COVID-19 was and still is a death threat. Our results show that an econometrician according to the metrics of the $RMSFEs$ can acquire 0.17, 0.26 and 0.16 percent forecasting gain in the three respective forecasting models, etc…$h = 1, h = 5$ and h=22 in the US 5-Year T-Note. In the US 2-Year T-Note, an econometrician can acquire 0.03, 0.12 and 0.38 forecasting gains in the $h = 1, h = 5$ and $h = 22$, respectively. Another forecasting gains of 0.74, 0.47 and 0.16 percent (in the h=1, h=5 and $h = 22$ model, respectively) that an econometrician can inference from is evident in the US 30-Year T-Bond Futures. On the other hand, an econometrician can obtain a forecasting loss of -0.01 and -0.03 percent in the $h = 1$ and $h = 5$ forecasting models of the US 10-Year T-Note.

According to the MSE-F statistics[7], the results of our out-of-sample models in the COVID-19 range for the US 5- and 2-Year T-Notes and the US 30-Year T-Bond are statistically significant at a 1 percent level of significance. The results of our out-of-sample models in the US 10-Year T-Note are statistically insignificant at all levels of

[6] MSE-F Critical value are 3.951, 1.518 and 0.616 at 10%, 5% and 1% level of significancy, respectively.
[7] The MSE-F statistic values are available on request. They are to be compared with the MSE-F critical values of 1.608, 0.85 and 0.53 at 10%, 5% and 1% level of significancy, respectively.

significance. It is worth notable that even in such a short period we can empirically see the predictive power of the EMVID for especially the US 5- and 2-Year T-Notes (the US 2-Year T-Note was previous insignificant) and the US 30-Year T-Bond. This has important implications for investor during periods of turmoil uncertainty due to epidemic and pandemic outbreak.

Our findings contribute to the existing literature by showing that uncertainty related to pandemics and epidemics has the ability to predict the volatility of the US Treasury securities. This is the first unique empirical evidence from previous literature related to the predictive power of uncertainties of various types (economic, financial, as well as geopolitical risk) for this asset class.

Table 1. Out-of-Sample Forecasting Gains

Horizon	RMSE0	RMSE1	FGs (RMSEs)
Panel A: CGB – 12th April 2000 to 20th February 2021			
h=1	0.0156	0.0156	0.0000
h=5	0.0041	0.0041	0.0000
h=22	0.0010	0.0010	0.0000
Panel B: ED - 06th July 2016 to 20th February 2021			
h=1	0.2803	0.2751	1.9008***
h=5	0.0748	0.0739	1.1812***
h=22	0.1407	0.1352	4.0592***
Panel C: FV - 02nd July 2013 to 20th February 2021			
h=1	0.0094	0.0091	3.3223***
h=5	0.0024	0.0024	0.0422***
h=22	0.0006	0.0006	0.0000
Panel D: TU - 09th May 2013 to 20th February 2021			
h=1	0.0036	0.0036	0.0000
h=5	0.0010	0.0010	0.0000
h=22	0.0002	0.0002	0.0000
Panel E: TY - 11th June 2013 to 20th February 2021			
h=1	0.0140	0.0140	0.0214***
h=5	0.0037	0.0037	0.0000
h=22	0.0010	0.0010	0.1012***
Panel F: US - 28th June 2013 to 20th February 2021			
h=1	0.0243	0.0243	0.2431***
h=5	0.0064	0.0064	0.1561***
h=22	0.0017	0.0017	0.1720***

Notes: The out-of-sample forecasting gain is computed as follows $FG = \left(\frac{RMSFE_0}{RMSFE_1} - 1\right) * 100$, where $RMSFE_0$ and $RMSFE_1$ are root mean squared forecast errors (RMSFEs) of the benchmark (eq 1) and extended HAV-RV model (eq 2), respectively. The entire sample was used as the in-sample range. Where *** indicates 1%. level of significance.

4. Conclusion

The role of the US Treasury securities as a premier “safe haven” during periods of uncertainty is well recognised in the financial market as well as in academia. The unprecedented levels of global uncertainty as a result of the COVID-19 outbreak have caused us to uniquely examine the predictive ability of the daily newspaper-based index uncertainty related to infectious diseases (EMVID) for the US Treasury securities’ realised volatility (RV). Extending the benchmark HAV-RV model by adding the EMVID index, our out-of-sample forecast shows significant evidence of the role played by the EMVIID index in explaining the future path of the US Treasury securities.

To evaluate the predictive power of the EMVID index in-depth, we conducted the out-of-sample forecast over the period that covers the COVID-19 episode. Our results depict that over this short period, the role of the EMVID index in forecasting the US Treasury securities under investigation is statistically significant except in the US 10-Year T-Note Futures. These findings have important implications for fund managers and investors during times of economic downturns.

Incorporating daily infectious diseases-related uncertainty in the forecasting model can help improve the structuring of the portfolio that includes the US 30-Year T-Bond and the US 2-and 5-Year T-Notes Futures as a hedging instrument in the financial market during periods of infectious diseases outbreak. Hence, the accurate forecast of this asset class is important. For future studies, it would be interesting to study how infectious diseases related uncertainty have affected other financial sectors.

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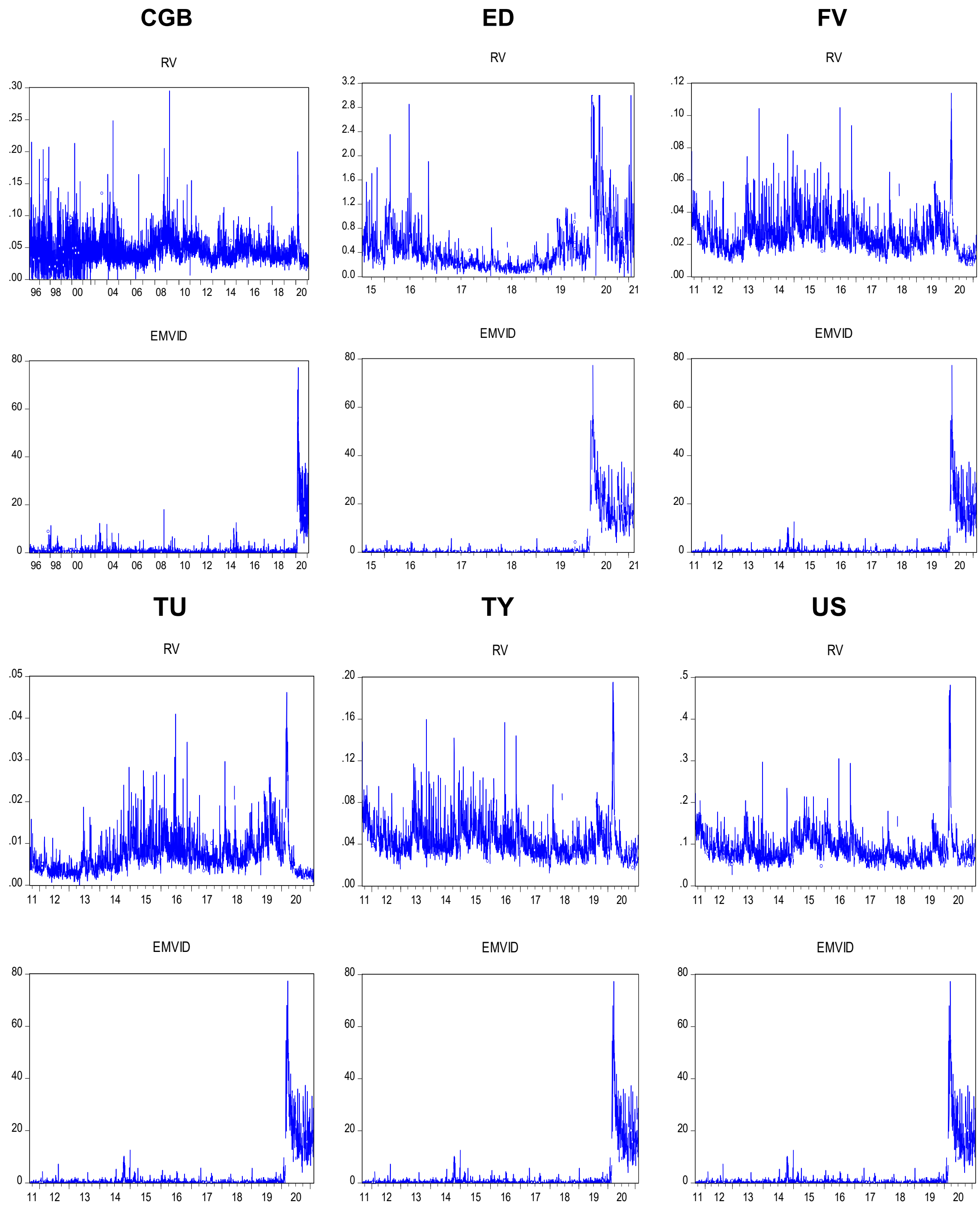
APPENDIX

Table A1. Summary Statistics.

	CGB		ED		FV		TU		TY		US	
Statistic	RV	EMVID	RV	EMVID	RV	EMVID	RV	EMVID	RV	EMVID	RV	EMVID
Mean	0.0445	1.3060	0.4807	3.7796	0.0259	2.3601	0.0074	2.5428	0.0444	2.4887	0.0903	2.5121
Median	0.0411	0.0000	0.3423	0.3100	0.0234	0.0000	0.0063	0.2700	0.0401	0.0000	0.0819	0.2750
Maximum	0.2952	77.3500	3.0000	77.3500	0.1139	77.3500	0.0462	77.3500	0.1955	77.3500	0.4820	77.3500
Minimum	2.97E-05	0.0000	0.0017	0.0000	0.0066	0.0000	4.24E-05	0.0000	0.0122	0.0000	0.0268	0.0000
Std. Dev.	0.0209	4.8883	0.4538	9.0005	0.0116	7.0357	0.0049	7.4484	0.0188	7.3779	0.0389	7.4261
Skewness	2.0972	6.8432	2.8002	3.1972	1.9687	4.3976	2.3692	4.3081	2.4889	4.3893	3.6647	4.3646
Kurtosis	15.2501	61.5901	13.5823	15.0222	10.3927	26.4097	12.5474	25.4003	14.5135	26.2867	28.6186	25.9530
Jarque-Bera	39050.65	843185.2	7728.853	9997.363	6576.916	58628.12	10693.11	54217.13	14757.18	58088.25	66032.79	56082.58
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	5590	5590	1294	1294	2250	2250	2259	2259	2251	2251	2232	2232

Notes: Table A1 represents the summary statistics of variables' Realised Volatility (RV) and the newspaper-based index uncertainty related to infectious diseases (EMVID). Std. Dev. is the standard deviation and p-value is the null hypothesis of normality associated with the Jarque-Bera test.

Figure A1. Data Plots



Notes: RV is the daily realised volatility estimation for the US Treasury securities; EMVID is the daily newspaper-based index uncertainty related to infectious diseases.