Measuring and Hedging Geopolitical Risk

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EC^2 on 'High dimensional modeling in time series'
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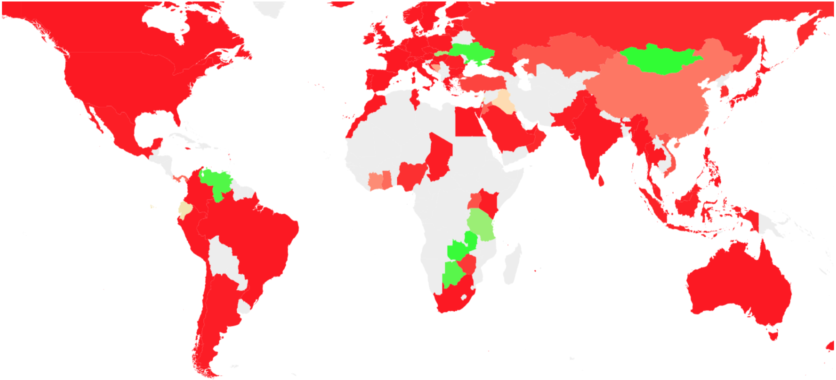
Motivation and the COVID-19 Pandemic



Colour-coded global volatility map from V-Lab, Volatility and Risk Institute, on March 17, 2020. Red colours represent high levels and green colours low levels of volatility.

The GEOVOL model

Consider the vector of returns $\boldsymbol{r}_t = (r_{1t}, \dots, r_{nt})'$ given by

$$\begin{aligned} \boldsymbol{f}_t &= \boldsymbol{w}_{t-1}' \boldsymbol{r}_t \\ \boldsymbol{r}_t &= r^f + \mathbf{B} \boldsymbol{f}_t + \text{diag}\{\sqrt{\boldsymbol{h}_t}\} \boldsymbol{e}_t, \end{aligned} \tag{1}$$

where $\mathbf{B}$ is an $(n \times p)$ matrix of risk exposures, $\boldsymbol{f}_t$ is a $(p \times 1)$ vector of factors and $\boldsymbol{h}_t = (h_1, \dots, h_n)'$ contains idiosyncratic conditional variances.

- Volatilities of asset returns move together.
- But idiosyncratic volatilities still co-move after factors have been extracted (Herskovic et al., 2016).

If factors are sufficient to reduce the correlations of residuals to zero,

$$\mathbb{E}_{t-1}(\boldsymbol{e}_t \boldsymbol{e}_t') = \mathbb{I}. \tag{2}$$

The GEOVOL model

New and testable observation. Shocks to volatility, measured as follows

$$\phi_{it} \equiv e_{it}^2 - 1 = \frac{(r_{it} - r^f - \beta_i' \boldsymbol{f}_t)^2 - h_{it}}{h_{it}}, \tag{3}$$

may be correlated. Let x_t be a latent variable and s_i a parameter

interpreted as a factor loading satisfying $x_t > 0$, $0 \leq s_i \leq 1$, $\mathbb{E}_{t-1}(x_t) = 1$, and $\mathbb{E}_{t-1}(x_t - 1)^2 = v_t$.

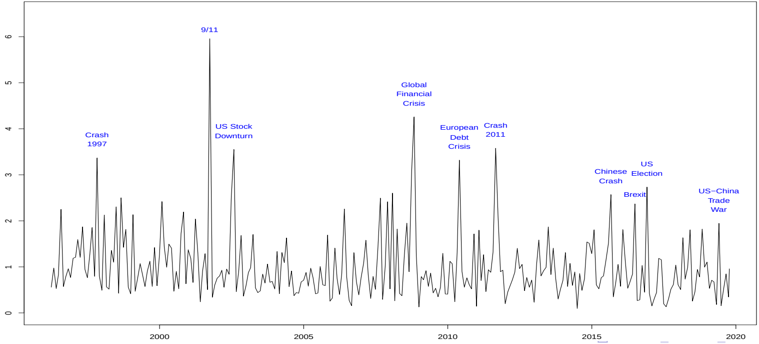
Consider the data generating process for the random variable

$$\begin{aligned} e_{it} &= \sqrt{g(s_i, x_t)}\epsilon_{it} \\ g(s_i, x_t) &\equiv s_i x_t + 1 - s_i, \end{aligned} \tag{4}$$

where $\epsilon_{it} \sim \mathcal{N}(0, 1)$. This implies $g(s_i, x_t)$ is non-negative and $\mathbb{E}[g(s_i, x_t)] = 1$, which satisfies $\mathbb{E}[e_{it}^2] = 1$ and (2).

Monthly GEOVOL of ACWI ETFs

1. Estimate a factor model with GARCH errors for each ETF.
2. Test for GEOVOL: test $H_{01} : \bar{\rho}_{\hat{\mathbf{e}}^2} = 0$, where $\hat{\bar{\rho}}_{\hat{\mathbf{e}}^2} = 0.0852$, and the test statistic 120.8658.
3. Iterate estimation of x, conditional on $\hat{s}$, and s conditional on $\hat{x}$.
4. Check the goodness of fit: test $H_{02} : \bar{\rho}_{\hat{\mathbf{e}}^2/\hat{\mathbf{g}}} = 0$, where $\hat{\bar{\rho}}_{\hat{\mathbf{e}}^2/\hat{\mathbf{g}}} = 0.0095$, and the test statistic -2.3118.



Conclusions

The GEOVOL model provides

- An empirical measure for the magnitude of common shocks to the volatilities of a wide range of assets.
- A novel explanation for why idiosyncratic volatilities co-move.
- A new way to formulate volatility factors.
- A new portfolio criterion for geopolitical risk diversification.