

Price discovery in equity markets: A state-dependent analysis of spot and futures markets — Supplementary Material

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1. Data

As a robustness check for our main results, we re-estimate our Markov-switching models using exchange traded fund (ETF) price data for the stock indices under consideration. ETFs are single tradeable assets that aim to track the performance of an underlying instrument. In particular, stock index ETFs based on physical replication can be perceived to represent the portfolio of its constituents. Usually, ETFs with different replication or tracking schemes as well as base currencies are available for the major stock indices. For our analysis, we focus on ETFs building on physical replication with the same currency as the underlying index constituents, and base our selection on their net asset value.

The selection of ETF contracts for European stock indices is difficult since the market is highly fragmented without a single dominant ETF contract in terms of net asset value. Specifically, we consider the *iShares Core DAX UCITS ETF (DE) - EUR ACC* contract traded on Xetra as a proxy for the DAX30. The ETF prices are observed over the same trading days and trading hours as the spot prices used for our main results. The *iShares Core EURO STOXX 50 UCITS ETF* traded at the Deutsche Boerse represents the EuroStoxx50 spot market and *iShares Core FTSE 100 UCITS ETF GBP* traded at the London Stock Exchange represents the FTSE100. Finally, we use the *SPDR S&P 500 ETF* from NYSE Arca. For the Nikkei225, we were unable to find appropriate intra-day ETF price data.

2. Additional results

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Table 1: Markov-switching vector error correction model for spot and futures prices (two-state model).

| | EuroStoxx50 | | FTSE100 | | DAX30 | | SP500 | |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | R1 | R2 | R1 | R2 | R1 | R2 | R1 | R2 |
| <i>Panel (a): Switching adjustment coefficients</i> | | | | | | | | |
| $\alpha_1(s_t)$ | -0.00001 (0.00024) | -0.00189 (0.00288) | 0.00036 (0.00039) | -0.01954 (0.00321) | -0.00002 (0.00036) | -0.00051 (0.00707) | 0.00026 (0.00058) | -0.01144 (0.01048) |
| $\alpha_2(s_t)$ | -0.00001 (0.00021) | 0.04710 (0.00231) | 0.00059 (0.00042) | 0.07493 (0.00358) | 0.00014 (0.00092) | 0.15298 (0.00246) | 0.00040 (0.00059) | -0.00517 (0.00976) |
| <i>Panel (b): Switching residual covariance matrix</i> | | | | | | | | |
| $\sigma_1^2(s_t)$ | $11.7 \cdot 10^{-8}$ | $7.71 \cdot 10^{-6}$ | $9.67 \cdot 10^{-8}$ | $7.54 \cdot 10^{-6}$ | $11.7 \cdot 10^{-8}$ | $8.87 \cdot 10^{-6}$ | $12.0 \cdot 10^{-8}$ | $11.7 \cdot 10^{-6}$ |
| $\sigma_{21}(s_t)$ | $3.98 \cdot 10^{-15}$ | $5.03 \cdot 10^{-15}$ | $4.38 \cdot 10^{-15}$ | $6.08 \cdot 10^{-15}$ | $4.34 \cdot 10^{-15}$ | $8.50 \cdot 10^{-15}$ | $2.62 \cdot 10^{-13}$ | $3.48 \cdot 10^{-11}$ |
| $\sigma_2^2(s_t)$ | $9.32 \cdot 10^{-8}$ | $6.18 \cdot 10^{-6}$ | $10.9 \cdot 10^{-8}$ | $1.43 \cdot 10^{-6}$ | $23.9 \cdot 10^{-8}$ | $6.78 \cdot 10^{-6}$ | $21.9 \cdot 10^{-8}$ | $11.3 \cdot 10^{-6}$ |
| <i>Panel (c): Test for residual autocorrelation</i> | | | | | | | | |
| | $m = 3$ | $m = 6$ | $m = 3$ | $m = 6$ | $m = 3$ | $m = 6$ | $m = 3$ | $m = 6$ |
| | 10.23 (0.094) | 13.42 (0.472) | 9.61 (0.126) | 23.14 (0.086) | 9.36 (0.157) | 18.23 (0.375) | 7.80 (0.253) | 13.64 (0.435) |
| <i>Panel (d): Transition probabilities</i> | | | | | | | | |
| | R1 | R2 | R1 | R2 | R1 | R2 | R1 | R2 |
| R1 | 0.949 | 0.302 | 0.919 | 0.321 | 0.858 | 0.387 | 0.857 | 0.366 |
| R2 | 0.051 | 0.698 | 0.081 | 0.679 | 0.142 | 0.613 | 0.143 | 0.634 |
| <i>Panel (e): Information/component shares of the futures market</i> | | | | | | | | |
| | R1 | R2 | R1 | R2 | R1 | R2 | R1 | R2 |
| CS (y_{1t}) | 0.000 | 0.961 | 1.000 | 0.793 | 0.891 | 0.997 | 1.000 | 0.000 |
| FSIS (y_{1t}) | 0.049 | 0.999 | 0.685 | 0.804 | 0.942 | 0.999 | 0.421 | 0.181 |

Note: Panel (a) reports the estimates of the adjustment coefficients for two regimes (R1 and R2) with standard errors in parentheses. The elements of the variance-covariance matrix are shown in panel (b). Panel (c) shows the results of vector portmanteau tests of the scaled residuals. P-values are given in parentheses. Panel (d) displays the estimated transition probabilities. Panel (e) reports component shares (CS) and Fernandes-Scherrer information shares (FSIS) for the futures market. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 1: This figures plots the smoothed probabilities of EuroStoxx50 (topleft), FTSE100 (topright), DAX30 (bottomleft), and SP500 (bottomright) over the average trading day (in UTC). The probabilities of being in state 1 and state 2 are marked in light-grey and grey, respectively. The probabilities sum up to one in each period.

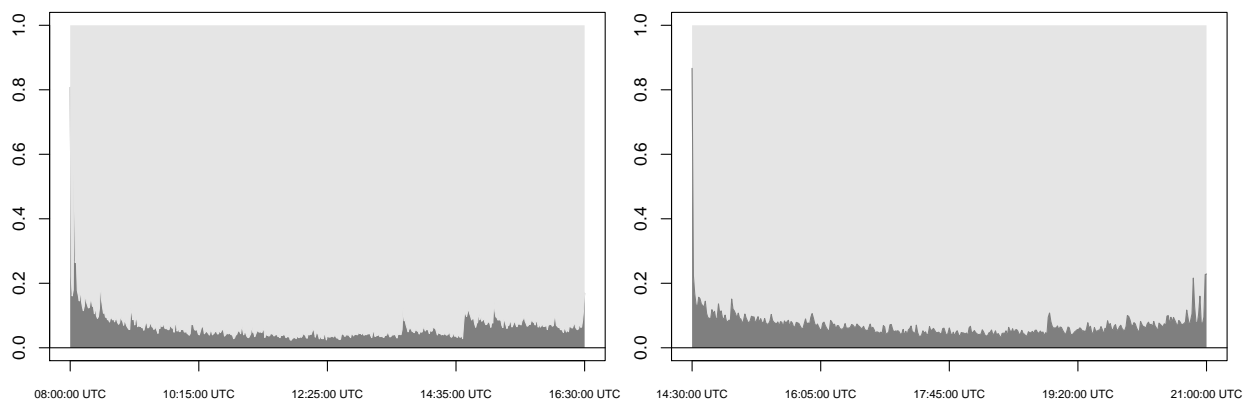
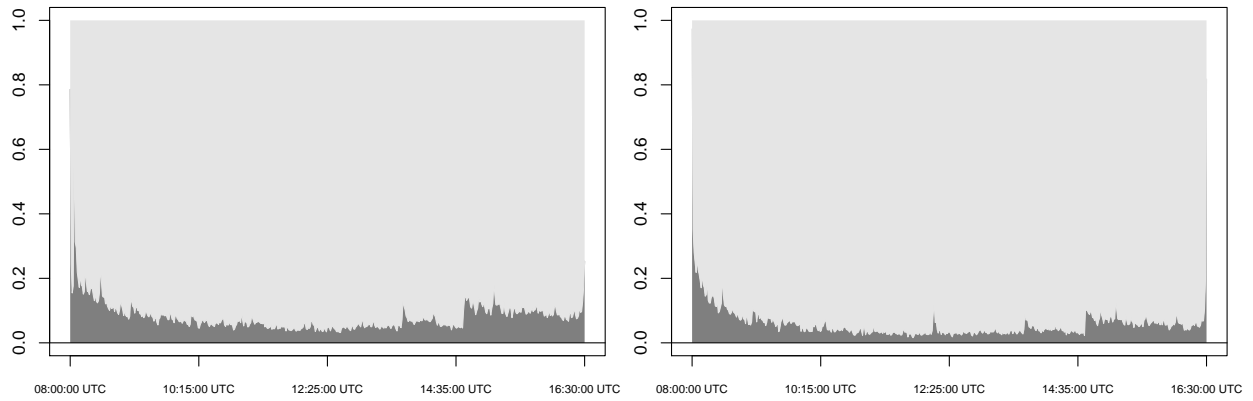
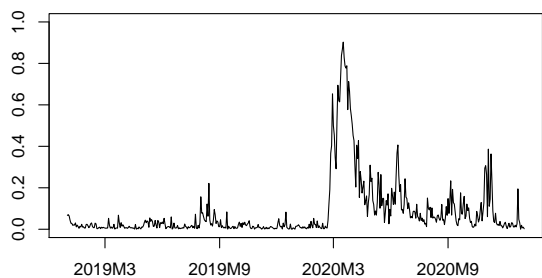
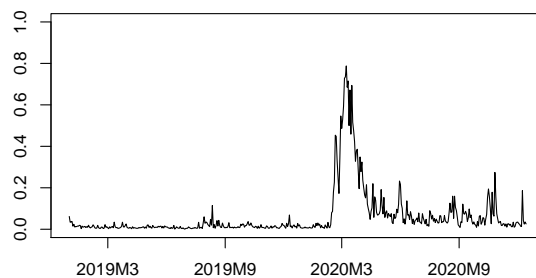


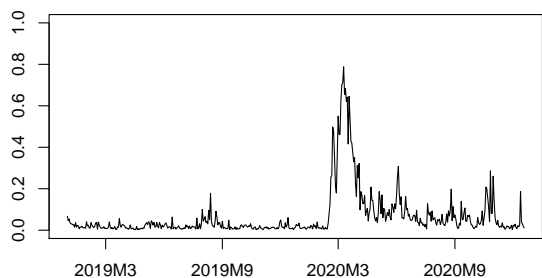
Figure 2: This figures plots the average smoothed state 2 probabilities of EuroStoxx50-Eurex (topleft), FTSE100-Euronext (topright), DAX-XFRA (mid-left), and SP500-Emini (mid-right) for each trading day along the time series plots of the VIX (bottomleft) and the equity market-related EUI (bottomright).



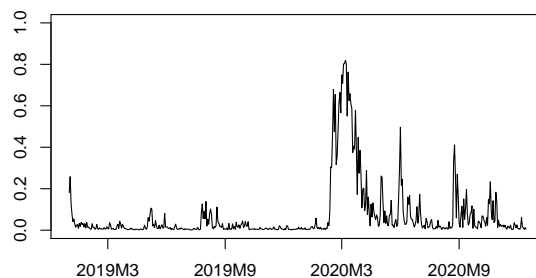
(a) EuroStoxx50



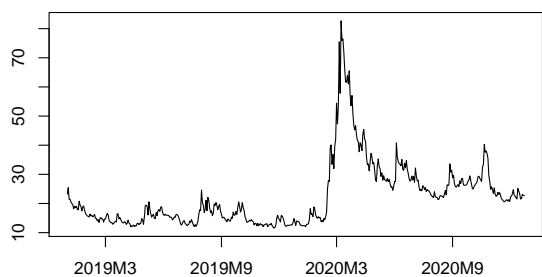
(b) FTSE100



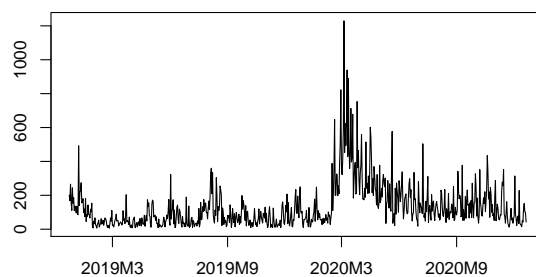
(c) DAX30



(d) SP500



(e) VIX



(f) EUI