MTHM059 Assignment 1

Sentimental Returns: Extended Acoustics

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Premise

- Better understanding of investor behaviour through unconventional data lenses.

- Edmans (2022)[1] showcased music as a groundbreaking dimension of investor behaviour.

- **Questions:**
  1. What role do mathematical models play?
  2. Can we enrich [1] for a more informative representation of investor behaviour?

Role of Mathematical Modelling & Music

- Unambiguous, communicable understanding of physical phenomena. Examples: Brownian motion, probability distributions, etc.

$$\begin{aligned} dS_t &= \mu S_t dt + \sqrt{\nu_t} S_t dW_t^s, \\ d\nu_t &= \kappa(\theta - \nu_t)dt + \xi\sqrt{\nu_t}\, dW_t^\nu \end{aligned} \qquad P(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

- Better data (observation) ⇔ better mathematical models.

- Why music? Simple: individual participants make markets → individuals use music to express mood, ∴ music influences the markets. A common idea, mathematised, provides a sharper understanding of a market dynamic.

Research Recap: SWAV, Data, Findings

- "Valence" proxies endogenous mood; [1] used stream-weighted average valence:

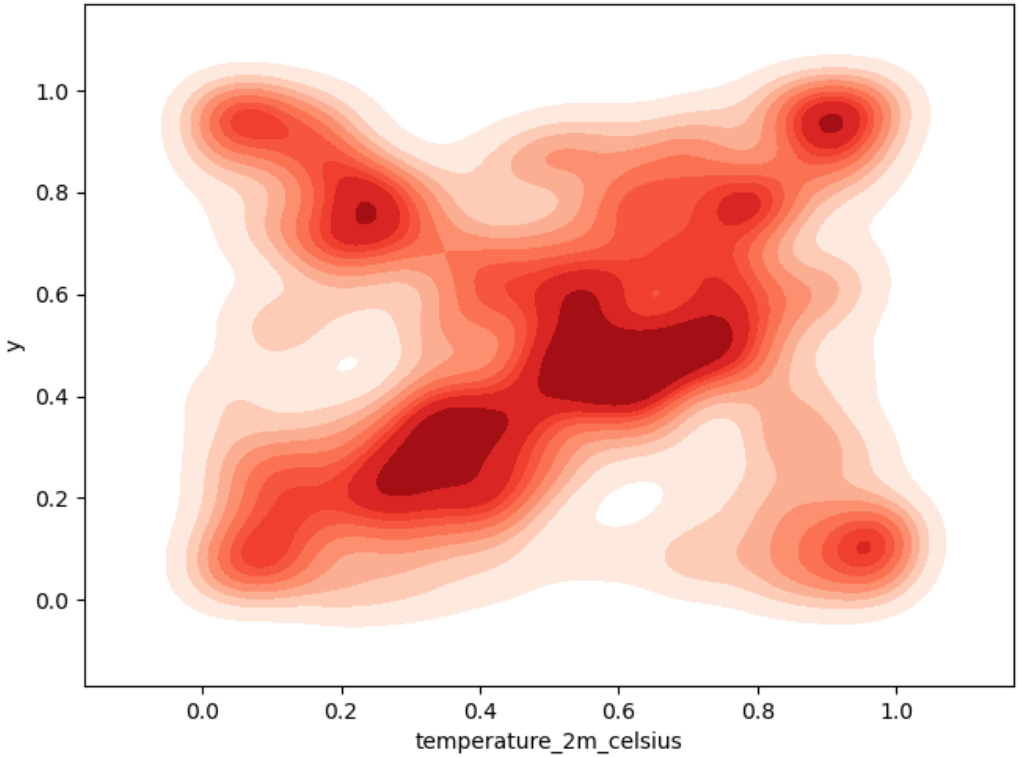
$$\mathrm{SWAV}_{i,d} = \sum_{j=1}^{200} \left(\frac{\mathrm{Streams}_{j,i,d}}{\sum_{j=1}^{200} \mathrm{Streams}_{j,i,d}} \cdot \mathrm{Valence}_{j,i,d} \right)$$

- Denoised with first-differencing, daily→weekly aggregation, and 2.5% winsorisation. ∴ $MS_{i,t} = SWAV_{i,t} - SWAV_{i,t-1}$.

- Preprocessed controls ⊃ weather, macroeconomics, EPU, volatility; local & global.

- Panel regressions & DID showed that a $+1\sigma$ in $MS \rightarrow +4.3\%$ annualised contemporaneous weekly return, with a next-week reversal of -3.7%. Results held across markets, local controls, market caps, and arbitrage limits.

Nonlinear Modelling – Copulae & TVP



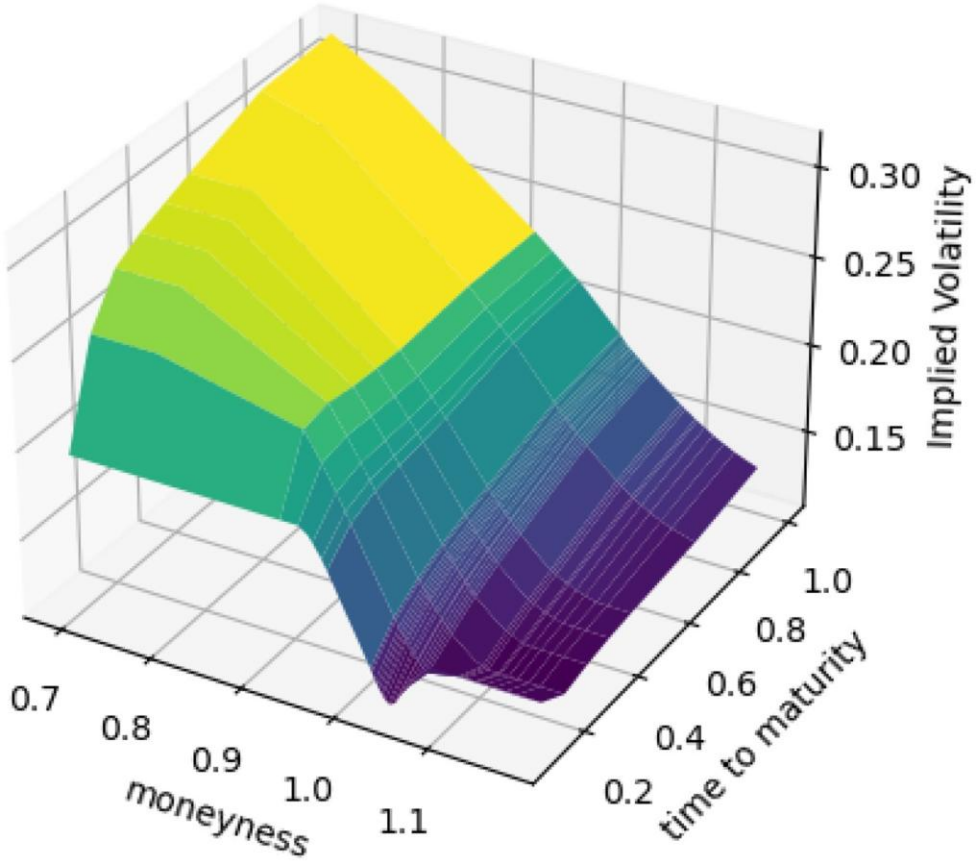
Sample Copula: Beverage sales vs. weather. Borrowed from [9].

Nonlinear modelling: Copulae uncover nonlinear relationships. Regime-switching models allow evolution of coefficients. Both reveal persistent & cascading effects [3, 4, 5, 6, 7, 8].

Image: Sample rank-based empirical copula showing regimes between weather (x-axis) and retail beverage sales (y-axis) after whitening & normalising. Dark red regions show high mass co-movement; lighter regions, lesser strength.

$$R_{i,t} = \alpha + \beta_1 \mathrm{MS}_{i,t} + \sum \Gamma \ \mathrm{Controls}_{i,t} + \varepsilon_{i,t} \quad \rightarrow \quad R_{i,t} = \alpha_t + \beta_{1,t} \ \mathrm{MS}_{i,t} + \sum_{i=1}^{N} \Gamma_{i,t} \ \mathrm{Controls}_{i,t} + \varepsilon_{i,t}$$

Volatility Surface Expansion



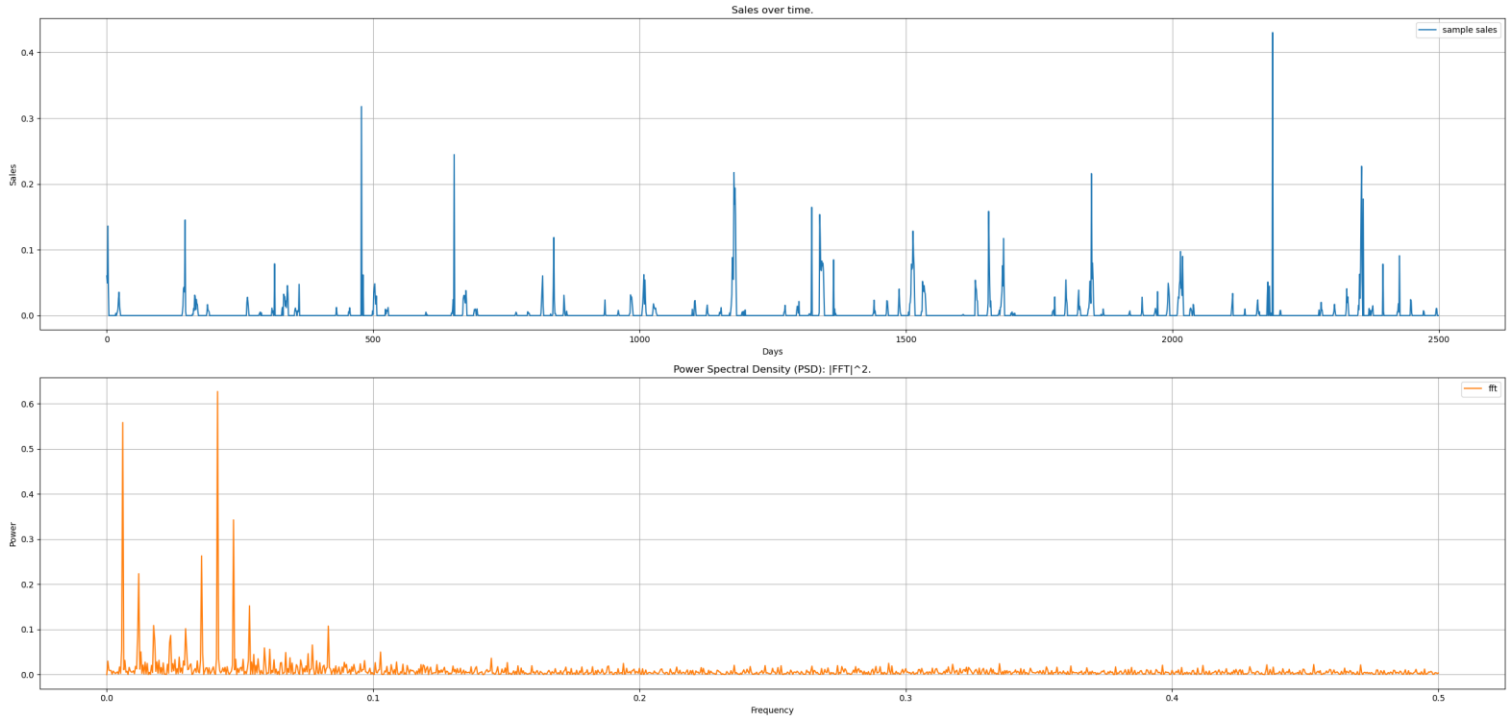
Sample IVS: SPX on 01/11/2021. Borrowed from [10].

IV Surfaces: Volatility is nonlinear, skewed, and shifts with market conditions. Research has highlighted a significant data-driven relationship between IVS, sentiment, and returns [4, 5].

Image: *how Implied Volatility (IV) changes over different option prices (moneyness) relative to the current market level, and simultaneously over time in the market (time to maturity, TTM). Longer TTM increases IV because the market has more time to move. Market levels lower than current have the highest IV; higher than current have the lowest – nonlinear & time-varying.*

Also a proxy for sentiment, because this spread indicates bearishness.

Frequency Transformations



Sample FFT: Shows how sales in time (top) transforms to frequency (bottom).

Spectral features: Fourier and EMD transformations shift time-signals into frequencies, highlighting periodic patterns. Literature shows that these refine nonlinear/surface analyses, and additional music descriptors beyond valence add further explanatory power [2, 5].

Image: *Sales over time represented in frequencies, highlighting periodic behaviour. Example specifically chosen to accentuate periodicities.*

References

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