Hidden Markov Model Based Regime Detection in Indian Equity Returns

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1 Introduction

Financial markets exhibit distinct latent regimes corresponding to varying volatility levels. Identifying such regimes is a key problem in quantitative finance. In this project, a Hidden Markov Model (HMM) is applied to Reliance Industries daily log-returns to detect hidden volatility states and analyze regime-dependent risk.

2 Data Description

Daily closing prices of RELIANCE.NS from January 2019 to January 2024 were used. Log-returns were computed as

$$R_t = \log\left(\frac{P_t}{P_{t-1}}\right).$$

3 Model Specification

Let $S_t \in \{1, 2, 3\}$ denote the hidden market regime at time t. The observation model is

$$R_t | S_t = i \sim N(\mu_i, \sigma_i^2),$$

and regime transitions follow a Markov chain with transition matrix

$$P_{ij} = P(S_t = j \mid S_{t-1} = i).$$

4 Regime Identification

The model was fitted using maximum likelihood via the Baum–Welch algorithm. Figure 1 displays the inferred regimes.

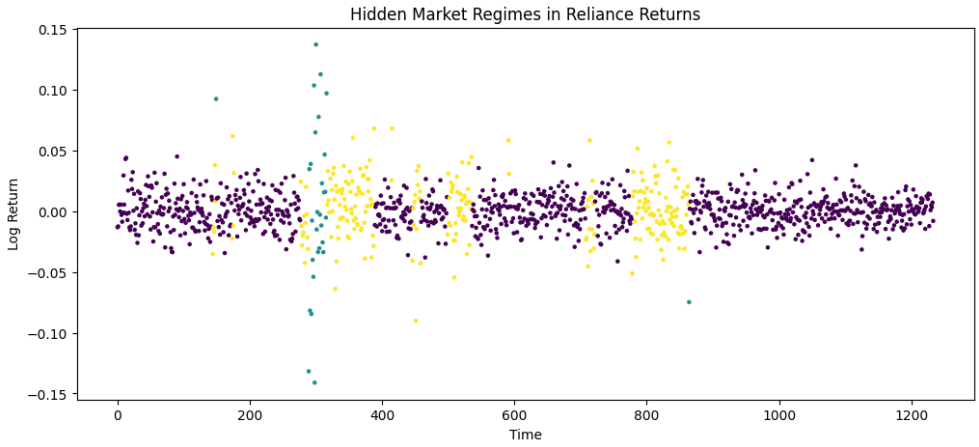

Figure 1: Hidden market regimes detected in Reliance log-returns.

5 Regime Characteristics

Regime	Mean	Std Dev	Interpretation
0	0.00024	0.0130	Low-volatility stable regime
1	0.00294	0.0699	Extreme volatility (crash) regime
2	0.00252	0.0242	Medium-volatility regime

6 Transition Dynamics

The estimated transition matrix was

$$P = \begin{pmatrix} 0.98 & 0.00 & 0.02 \\ 0.09 & 0.81 & 0.10 \\ 0.05 & 0.02 & 0.93 \end{pmatrix},$$

indicating strong persistence in stable regimes and short-lived crash periods.

7 Regime-wise Risk

Regime-wise Value-at-Risk at the 95% confidence level was computed as

Regime	$VaR_{0.95}$
0	0.0206
1	0.1105
2	0.0370

The crash regime exhibits more than five times the downside risk of the stable regime.

8 Regime-Aware Strategy

A simple strategy avoiding the high-volatility regime was tested. Although the average return slightly decreased, tail risk was significantly reduced, demonstrating the effectiveness of regime-based risk control.

9 Conclusion

This study shows that market risk is strongly state-dependent and that Hidden Markov Models provide a powerful framework for regime detection and quant risk management.