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Market Regime Detection with Hidden Markov Models (HMMs)

Several academic and practical studies have applied HMMs to detect **market regimes** (e.g. bull vs bear markets or high vs low volatility periods) and to adapt trading strategies based on hidden states. Below is a summary of key papers and implementations – especially those with open-source code – highlighting their data, number of regimes, features, modeling assumptions, and code availability:

- **Wang, Lin & Mikhelson (2020)** – *Regime-Switching Factor Investing with HMMs:* This study trained a Gaussian HMM on ~10 years of S&P 500 daily data to classify **three regimes** (interpreted as bull, bear, and neutral/"sideways" markets) [1] [2]. The HMM used **daily returns and a volatility measure** as features, modeling them with a full covariance matrix to capture return–volatility correlation [3] [4]. The authors integrated the HMM signals into a strategy that rotates among factor portfolios, and found that over 2017–2020 the regime-switching strategy outperformed static factor models in returns and risk metrics [5]. *Open-source implementation:* The authors utilized Python's `hmmlearn` library and have released their HMM trading code (e.g. the **HMM_Trading** repository) on GitHub [6].

- **Kim, Jeong & Lee (2019)** – *Global Asset Allocation Using an HMM:* This paper applied HMMs to **multi-asset portfolios** over a 15-year period (2004–2018) across global asset classes [7]. Each asset class was modeled as having two latent **phases** (bull vs bear), enabling dynamic allocation: the HMM-driven strategy **increased equity weight in bull phases and shifted to bonds in bear phases**, adjusting portfolio weights in response to regime changes [7]. Using weekly ETF data for 10 broad asset classes (and finer subdivisions into 22 classes), the authors showed that the HMM-based strategy achieved higher performance (e.g. positive Jensen's alpha and Treynor–Mazuy timing gamma) compared to a momentum strategy [8] [9]. *(Code:* Implemented in R using the `depmixS4` HMM package; code not explicitly provided in the paper.)

- **Majumder, Ji & Neerchal (2023)** – *Linked HMMs for Sector-wise Bull/Bear Regimes:* This recent work fits a **multivariate "linked" HMM** to weekly returns of S&P 500 stocks (2011–2016) by sector [10]. Each of the 12 GICS sectors has its own two-state HMM (bull or bear sector trend), and a Gaussian copula links these state processes, allowing **correlated regime switches** across sectors [11]. This hierarchical HMM (an advanced regime model) captures sector-specific heterogeneity in bull/bear dynamics. The authors constructed optimal stock portfolios based on the inferred regimes and found that out-of-sample (2016–2017) the HMM-driven portfolios achieved annual gains comparable to the S&P 500 benchmark, while balancing reward-risk tradeoffs [12]. *(Code:* Methodology described in ArXiv/Sankhya paper; no public code repository mentioned.)

- **Yuan & Mitra (2016)** – *Market Regime Identification (FTSE 100 & Euro Stoxx 50):* This study used an HMM to detect **unobserved market sentiment** states (bullish vs bearish) in European index data [13]. Using daily returns of FTSE-100 and EuroStoxx-50, the HMM captured regime-dependent **stylized facts** – e.g. one state exhibited higher volatility (fat-tailed returns) and the other lower volatility – improving on a single-regime Geometric Brownian Motion fit [13]. The **two-state HMM** provided a "market signal" that could forecast future conditions better than a static model [14]. *(Code:* Not provided; likely implemented with a standard HMM toolkit by the authors at OptiRisk Systems.)

- **Donninger (2017)** – *HMM for Bull/Bear Switching and Tail-Risk:* Donninger's working papers (SSRN) developed an HMM to time **bull vs bear market regimes** for tactical allocation. An initial study used a 2-state HMM on S&P 500 and **VIX futures** to trigger tail-risk hedges (the "Wool-Milk-Sow" strategy), and a follow-up applied the model to various equity indices and to switch between equity and Treasury bond ETFs [15]. The HMM-based regime filter signaled when to shift into safe assets (or leveraged ETFs) during bearish regimes, demonstrating improved downside protection and **extending the promising results** of the original approach [15]. *(Code:* Not openly provided in the papers; the methodology is described conceptually, focusing on the HMM's regime probabilities to drive trading rules.)

- **Fu & Wu (2017)** – *HMM vs. Machine Learning for Market Trend Prediction:* This conference paper (Xiamen University) proposed an HMM-based strategy for **index trend prediction** and compared it to moving-average and k-means clustering methods [16]. The authors generated many technical **features** (e.g. price, volume, indicators) from Chinese CSI 300 index and S&P 500 index data, then used a feature selection process where each candidate feature's utility was evaluated via HMM likelihood [17] [18]. A multi-feature HMM was trained (number of hidden states not explicitly stated, but effectively distinguishing "strong" vs "weak" market conditions), and used to predict the next day's market state for a trading strategy. The HMM strategy achieved **more stable and profitable returns** and earlier bear-market warnings than a double moving-average crossover or unsupervised k-means regime clustering [18]. *(Code:* The study used Python and the TuShare financial data API; no public code link, but the paper's flowchart and results illustrate the implementation.)

- **Novak (2020)** – *HMM + SVM for Regime Detection (GitHub project):* In a practical study, Novak uses an HMM to classify the **iShares MSCI EAFE index** (an international equity ETF) into bull vs bear regimes, and then applies an unsupervised SVM to refine these clusters [19]. The HMM (applied to ~20 years of daily prices) proved effective at quickly identifying regime shifts, and the additional one-class SVM helped separate subtle regime variations [20]. The combined model's outputs are intended to inform a trading strategy for market-on-open orders by predicting short-term market direction [21]. *The full code and report are open-sourced* in a GitHub repository, allowing replication of the HMM/SVM approach [19].

Each of the above works demonstrates that Hidden Markov Models can effectively uncover **hidden market states** – such as bull vs bear trends or low vs high volatility regimes – and that exploiting these states can improve investment decisions. Many authors also share their implementations or data: e.g. Wang *et al.* (2020) provide a public Python notebook for their 3-state HMM on S&P 500 [6], and Novak's GitHub project offers a reproducible HMM/SVM pipeline [19]. These resources underscore the practical applicability of HMM-based regime detection in finance, enabling analysts to detect regime shifts and adapt trading or asset allocation strategies accordingly.

Sources:

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5. Donninger (2017), *"Trading Bull- and Bear-Markets with a Hidden Markov Model,"* SSRN Working Paper [15] .
6. Fu & Wu (2017), *"Quantitative Trading Strategy of Market States Prediction Based on HMM,"* in **Proc. MSMEE 2017** [16] [18] .
7. Novak (2020), *"Regime Detection using Machine Learning (HMM & SVM),"* GitHub repository and report [19] .

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[19] [20] [21] **GitHub - theo-dim/regime_detection_ml: Regime detection in historical markets using Hidden Markov Models (HMM) and Support Vector Machines (SVM).**
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