Modeling Volatility Changes in the Stock Market using Inhomogeneous Markov Chains

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Volatility in the stock market serves as a pivotal measure of the magnitude and velocity of stock price movements. It is well established that higher volatility stocks experience more extreme price fluctuations, while lower volatility stocks tend to maintain price stability. Sudden shifts in volatility present substantial risks to investors for two primary reasons:

1) Elevated levels of volatility often coincide with significant downturns in the market, causing substantial concerns for market participants.
2) Volatility plays a fundamental role in the pricing of financial derivatives, particularly options. Consequently, any substantial alterations in volatility can significantly affect the premium prices for option contracts.

This project aims to utilize the Chicago Board of Exchange Volatility Index ("VIX") as a reliable gauge of market volatility. The VIX is one of the most widely accepted indicators for assessing market volatility and is calculated upon using 30 day option prices of constituent stocks within the S&P 500. Different values of the VIX will serve as different states within our state space. For instance, VIX values less than 20 will define a state of low volatility, VIX values between 20 and 30 will designate a neutral state, and VIX values exceeding 30 will represent a high volatility state. Since the transition probabilities vary over time, and due to a number of variable factors, including, but not limited to, current events, corporate earnings, market sentiment, Federal Reserve Meetings, and historical market performance over specific time intervals, thus Inhomogeneous Markov Chains will be used to model changes in the VIX. A regression analysis using a minimum likelihood estimator ("MLE") will be used to identify the transition probabilities at certain points in time.

Goals:

1) Develop a sophisticated Inhomogeneous Markov Chain model to describe and predict VIX changes accurately.
2) Predict volatility shifts with some level of accuracy.
3) Discuss potential applications and implications of this model for future research, financial risk management, and investment strategies.

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