Dynamic Asset Allocation - Identifying Regime Shifts in Financial Time Series to Build Robust Portfolios

Long-term investors can often bear the risk of outsized market movements or tail events more easily than the average investor; for bearing this risk, they hope to earn significant excess returns. Rebalancing periodically to a fixed benchmark allocation, however, is not the way to do this. In the presence of time-varying investment opportunities, portfolio weights should be adjusted as new information arrives to take advantage of favorable regimes and reduce potential drawdowns. This thesis contributes to a better understanding of financial markets' behavior in the form of a model-based framework for dynamic asset allocation. Regime-switching models can match financial markets' tendency to change their behavior abruptly and the phenomenon that the new behavior often persists for several periods after a change. Regime shifts lead to time-varying parameters and, in addition, the parameters within the regimes and the transition probabilities change over time. Using recursive and adaptive estimation techniques to capture this, we are able to better reproduce the volatility persistence that dynamic asset allocation benefits from. With this approach it is sufficient to distinguish between two regimes in stock returns in order for it to be profitable to change asset allocation based solely on the inferred regimes, both in a single- and multiasset universe. We advocate the use of model predictive control for translating forecasts into a dynamic strategy and controlling drawdowns by solving a multi-period optimization problem. We implement this based on forecasts from a multivariate hidden Markov model with time-varying parameters. Our results show that a substantial amount of value can be added by adjusting the asset allocation to the current market conditions, rather than rebalancing periodically to a static benchmark. By proposing a practical approach to drawdown control, we demonstrate the theoretical link to dynamic asset allocation and the importance of identifying and acting on regime shifts in order to limit losses and build robust portfolios.
In this article, model predictive control (MPC) is used to dynamically optimize a portfolio based on forecasts of the mean and variance of financial returns from a hidden Markov model with time-varying parameters. There are computational advantages to using MPC when estimates of future returns are updated every time a new observation becomes available, since the optimal control actions are reconsidered anyway. MPC outperforms a static decision rule for changing the allocation and realizes both a higher return and a significantly lower risk than a buy-and-hold investment in various major stock market indices. This is after accounting for transaction costs, with a one-day delay in the implementation of allocation changes, and with zero-interest cash as the only alternative to the stock indices. Imposing a trading penalty that reduces the number of trades is found to increase the robustness of the approach.
Multi-period portfolio selection, Meanvariance optimization, Model predictive control, Hidden Markov model, Adaptive estimation, Forecasting

Multi-Period Trading via Convex Optimization

We consider a basic model of multi-period trading, which can be used to evaluate the performance of a trading strategy. We describe a framework for single-period optimization, where the trades in each period are found by solving a convex optimization problem that trades off expected return, risk, transaction cost and holding cost such as the borrowing cost for shorting assets. We then describe a multi-period version of the trading method, where optimization is used to plan a sequence of trades, with only the first one executed, using estimates of future quantities that are unknown when the trades are chosen. The single period method traces back to Markowitz; the multi-period methods trace back to model predictive control. Our contribution is to describe the single-period and multi-period methods in one simple framework, giving a clear description of the development and the approximations made. In this paper, we do not address a critical component in a trading algorithm, the predictions or forecasts of future quantities. The methods we describe in this paper can be thought of as good ways to exploit predictions, no matter how they are made. We have also developed a companion open-source software library that implements many of the ideas and methods described in the paper.

Detecting change points in VIX and S&P 500: A new approach to dynamic asset allocation

The purpose of dynamic asset allocation (DAA) is to overcome the challenge that changing market conditions present to traditional strategic asset allocation by adjusting portfolio weights to take advantage of favorable conditions and reduce potential drawdowns. This article proposes a new approach to DAA that is based on detection of change points without fitting a model with a fixed number of regimes to the data, without estimating any parameters and without assuming a specific distribution of the data. It is examined whether DAA is most profitable when based on changes in the Chicago Board Options Exchange Volatility Index or change points detected in daily returns of the S&P 500 index. In an asset universe consisting of the S&P 500 index and cash, it is shown that a dynamic strategy based on detected change points significantly improves the Sharpe ratio and reduces the drawdown risk when compared with a static, fixed-weight benchmark.
Long Memory of Financial Time Series and Hidden Markov Models with Time-Varying Parameters

Hidden Markov models are often used to model daily returns and to infer the hidden state of financial markets. Previous studies have found that the estimated models change over time, but the implications of the time-varying behavior have not been thoroughly examined. This paper presents an adaptive estimation approach that allows for the parameters of the estimated models to be time varying. It is shown that a two-state Gaussian hidden Markov model with time-varying parameters is able to reproduce the long memory of squared daily returns that was previously believed to be the most difficult fact to reproduce with a hidden Markov model. Capturing the time-varying behavior of the parameters also leads to improved one-step density forecasts. Finally, it is shown that the forecasting performance of the estimated models can be further improved using local smoothing to forecast the parameter variations.
Hidden Markov models are often used to capture stylized facts of daily returns and to infer the hidden state of financial markets. Previous studies have found that the estimated models change over time, but the implications of the time-varying behavior for the ability to reproduce the stylized facts have not been thoroughly examined. This paper presents an adaptive estimation approach that allows for the parameters of the estimated models to be time-varying. It is shown that a two-state Gaussian hidden Markov model with time-varying parameters is able to reproduce the long memory of squared daily returns that was previously believed to be the most difficult fact to reproduce with a hidden Markov model. Capturing the time-varying behavior of the parameters also leads to improved one-step predictions.

**Long memory of financial time series and hidden Markov models with time-varying parameters**

Hidden Markov models are often used to capture stylized facts of daily returns and to infer the hidden state of financial markets. Previous studies have found that the estimated models change over time, but the implications of the time-varying behavior for the ability to reproduce the stylized facts have not been thoroughly examined. This paper presents an adaptive estimation approach that allows for the parameters of the estimated models to be time-varying. It is shown that a two-state Gaussian hidden Markov model with time-varying parameters is able to reproduce the long memory of squared daily returns that was previously believed to be the most difficult fact to reproduce with a hidden Markov model. Capturing the time-varying behavior of the parameters also leads to improved one-step predictions.

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Regime-Based Versus Static Asset Allocation: Letting the Data Speak

Regime shifts present a big challenge to traditional strategic asset allocation. This article investigates whether regime-based asset allocation can effectively respond to changes in financial regimes at the portfolio level, in an effort to provide better long-term results than more static approaches can offer. The authors center their regime-based approach around a regime-switching model with time-varying parameters that can match financial markets’ tendency to change behavior abruptly and the fact that the new behavior often persists for several periods after a change. In an asset universe consisting of a global stock index and a global government bond index, they show that, even without any level of forecasting skill, holding a static portfolio may not be optimal.

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Stylised facts of financial time series and hidden Markov models in continuous time

Hidden Markov models are often applied in quantitative finance to capture the stylised facts of financial returns. They are usually discrete-time models and the number of states rarely exceeds two because of the quadratic increase in the number of parameters with the number of states. This paper presents an extension to continuous time where it is possible to increase the number of states with a linear rather than quadratic growth in the number of parameters. The possibility of increasing the number of states leads to a better fit to both the distributional and temporal properties of daily returns.

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Nystrup, Peter (Intern)
Supervisor:
Hansen, Bo William (Ekstern)
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