Entropy, the Information Processing Cycle, and the Forecasting of Bull and Bear Market Peaks and Troughs

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ABSTRACT

Many econophysics applications have modeled financial systems as if they were pure physical systems devoid of human limitations and errors. On the other hand, traditional financial theory has ignored limits that physics would impose on human interactions, communications, and computational abilities. The entropic yield curve blends the physical and human financial worlds in a new, powerful, and surprisingly simple way. This article uses this information theoretic perspective to provide a new explanation of the dynamics and timing of financial cycles. Additionally, the entropic yield curve offers a new method of forecasting market peaks and troughs.

KEYWORDS

Bear Market, Bond, Bull Market, Burnashev, Econophysics, Entropy, Equity, Information Theory, Shannon Entropy

INTRODUCTION

The modeling and forecasting of the current and future states of financial systems is of extreme importance to a wide variety of financial actors. The appropriateness of portfolio weightings and other assumptions vary greatly depending on the financial cycle. More accurate determination of the timing of the emergence of bull and bear markets could vastly improve the performance of financial products while simultaneously reducing overall risk.

A bear market is indicative of a severe slowdown in the economy. A popular definition is a decline of 20 percent or more in a representative equity market. On the other hand, a bull market is generally characterized by a growing and expanding economy. Equities tend to rise during these periods. Economies spend on average about 80% of their time in bull markets and 20% in the bearish time periods (Albuquerque, Eichenbaum, Papanikolaou, Rebelo, & Sergio, 2015).

Importantly Albuquerque et al. (2015) found that during bull markets equity returns average 14.2% but tend to fall to -15.5% in bear markets. Reducing risk exposure before the onset of a bear market and relaxing those constraints before the beginning of a bull market would be extremely beneficial to the portfolio returns of market participants.

Several methods have been used to model and forecast large movements in the financial markets. Kole and Dijk (2017) broadly group these methods into parametric and nonparametric categories.

They find that non-parametric models perform well in in-sample identification of market states while parametric models such as Markov switching perform better in the forecasting of the future states of markets. Kritzman, Li, Page, and Rigobon (2011) derived a formula for an economy's absorption ratio which describes the degree of coupling in financial markets. The greater the coupling the greater the current and future potential riskiness of financial markets. Jorion (1995) studied the predictive power of the implied volatility skew for market volatility and while it was found to be biased the volatility skew outperformed times series models. Risso (2008) utilized entropic concepts and found that as financial market informational efficiency decreases the probability of a market crash rises.

The aim of this paper is to introduce a new tool to help practitioners determine when equities are near the start of a bull or bear market or somewhere in-between. Using a new technique Parker (2017) estimated the information processing efficiency of the economy. This new measure was shown to be useful in the prediction of financial downturns. That analysis is extended in the current paper to explain and predict the current and future states of the full cycle of financial markets in a new and intuitive way. This new variable can be used by actors in real-time to get a daily snapshot of the current and probable future states of financial markets and more accurately time the emergence of bull and bear markets.

MATERIALS AND METHODS

Parker (2017) developed an alternative derivation of the yield curve. This derivation is based on Shannon type entropy or information loss as described by Ben-Naim (2017), and combined with Burnashev's formula for the error exponent of communication systems (Burnashev, 1976). An estimate of the information processing efficiency of the economy (R/C) could found using actual yield rates.

Using this alternative derivation, Parker (2017) demonstrated that differing levels of R/C could generate the different regimes of the entropically derived yield curve. These regimes have an equivalent representation in the popular Nelson-Siegel specification of the yield curve (Nelson & Siegel, 1987). The current paper extends the previous research by more closely examining the time evolution R/C during bull and bear markets. As demonstrated empirically R/C rises, reaches a maximum, and then falls in a cyclical pattern. The evolution of this information process provides a new and intuitive explanation of the boom and bust financial cycles as seen from an information theoretic perspective.

The entropic yield curve was derived in Parker (2017) by blending concepts from information theory with traditional financial ideas. Information whether it is communicated through space as traditionally imagined or through time can be lost, corrupted, or otherwise misprocessed. An economy's efficiency in processing and communicating information is related to the economy's interest rates through the following entropic yield curve equation:

$$r_{parker} = B_0 + \frac{\ln\left(\sqrt{t}\right)}{t}\left(1 - e^{-C_1\left(1-\frac{R}{C}\right)}\right) - \frac{\ln\left(\sigma\right)}{t}\left(e^{-C_1\left(1-\frac{R}{C}\right)}\right) \tag{1}$$

$\frac{R}{C}$ is the implied relative information processing rate, where from Burnashev (1976):

$$p = e^{-C_1\left(1-\frac{R}{C}\right)} \tag{2}$$

In the entropic yield curve t represents the term to expiration, B_0 is the asymptotic long rate such as the 30-year bond yield, R is the current economic information set, and C is the economy's

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