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Efficient or adaptive markets? Evidence from major stock markets using very long run historic data

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ABSTRACT

This paper empirically investigates the Adaptive Market Hypothesis (AMH) in three of the most established stock markets in the world; the US, UK and Japanese markets using very long run data. Daily data is divided into five-yearly subsamples and subjected to linear and nonlinear tests to determine how the independence of stock returns has behaved over time. Further, a five-type classification is proposed to distinguish the differing behaviour of stock returns. The results from the linear autocorrelation, runs and variance ratio tests reveal that each market shows evidence of being an adaptive market, with returns going through periods of independence and dependence. However, the results from the nonlinear tests show strong dependence for every subsample in each market, although the magnitude of dependence varies quite considerably. Thus the linear dependence of stock returns varies over time but nonlinear dependence is strong throughout. Our overall results suggest that the AMH provides a better description of the behaviour of stock returns than the Efficient Market Hypothesis.

1. Introduction

The Efficient Market Hypothesis (EMH) defined by Fama (1970), has been one of the most important and documented theories in finance over the last 40 years. In broad terms, a market is efficient if its price reflects all relevant information immediately. Thus it is impossible to exploit any information set to predict future price changes. The weak-form version of market efficiency has become the most commonly tested form of the hypothesis in the empirical literature. The weak-form asserts that prices already reflect all information that can be derived by examining past market trading data such as the history of past prices, trading volume etc. If prices were predictable and profits could be made by using historical data, arbitrage would eliminate these profits in an efficiently operating market. Therefore there should be no predictability in security prices.

However, several important studies have shown that stock returns do not follow random walks (see, for example Fama & French, 1988; Lo & MacKinlay, 1988; Brock, Lakonishok, & LeBaron, 1992; Jegadeesh & Titman, 1993). This has led to an explosion of literature examining the validity of the EMH in developed and developing countries (see, for example, Opong, Mulholland, Fox, & Farahmand, 1999; Lim, Brooks, & Hinich, 2008; Borges, 2010). Nevertheless, the majority of these studies have one major shortcoming. They use statistical tests to evaluate whether a market is efficient over the whole of some predefined period. This means that market efficiency is treated as an all-or-nothing condition. However it is reasonable to expect market efficiency to evolve over time due to varying underlying market factors, such as institutional, regulatory and technological changes and possibly the demography behaviour of market participants.

To accommodate the notion of a changing degree of market efficiency over time, Lo (2004) proposes a new version of the EMH derived from evolutionary principles. Lo argues that valuable insights can be derived from the biological perspective and calls for an evolutionary alternative to market efficiency. This paradigm is called the Adaptive Market Hypothesis (AMH) under which the EMH and market inefficiency can co-exist in an intellectually consistent manner.

Lo (2005) states that individuals act in their own self-interest, but they make mistakes. They learn from these mistakes and adapt, and that competition drives adaptation and innovation. Finally evolution determines market dynamics. The AMH provides a number of practical implications within finance. Firstly, the risk premium varies over time according to the stock market environment and the demographics of investors in that environment. The second implication is that arbitrage opportunities do exist from time to time in the market. Thus from an evolutionary viewpoint, active liquid financial markets imply that profit opportunities must exist. However as they are exploited, they disappear. But new opportunities are continually being created as certain species/traders die out and rather than move towards a higher degree of efficiency the AMH implies that complex market dynamics such as trends,

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panics, bubbles and crashes are continually witnessed in natural market ecologies. The third implication is that investment strategies are successful or unsuccessful, depending on the particular market environment. Contrary to the EMH, the AMH implies that investment strategies may decline for a time, and then return to profitability when environmental conditions become more conducive to such strategies. A consequence of this implication is that market efficiency is not an all-or-nothing condition, but is a characteristic that varies continuously over time and across markets. Lo (2005) argues that convergence to equilibrium is neither guaranteed nor likely to occur and that it is incorrect to assume that the market must move towards some ideal state of efficiency.

The AMH has gained increasing attention in the recent academic literature. Lim and Brooks (2006) examine the evolving efficiency of developed and developing stock markets through the portmanteau bicorrelation test statistic. Using a rolling sample approach, they find that the degree of market efficiency varies through time in a cyclical fashion. Todea, Ulici, and Silaghi (2009) study the profitability of the moving average strategy over windows using linear and nonlinear tests. They report that returns are not constant over time, but rather episodic. Ito and Sugiyama (2009) examine the time-varying autocorrelation of monthly S&P500 returns. They show that the degree of market efficiency varies over time, with the market being most inefficient during the late 1980s and most efficient around the year 2000. Kim, Shamsuddin, and Lim (2011) investigate the AMH using the return predictability of the daily and weekly DJIA from 1900 to 2009. They use two autocorrelation tests (variance ratio and portmanteau) and a generalised spectral test to obtain monthly measures of the degree of stock return predictability by applying a moving-subsample window. They find strong evidence that return predictability fluctuates over time in a similar way to that described by Lo and that the US market has become more efficient after 1980. They also use regression analysis to determine how the return predictability over time is related to changing market and economic conditions. They find that there is no return predictability during market crashes, while economic and political crises are associated with a high degree of return predictability. Smith (2011) investigates the adaptive nature of fifteen European emerging stock markets, along with the developed markets of Greece, Portugal and the UK. Utilising rolling window variance ratio tests for the period February 2000 to December 2009 they find that the most efficient markets were the Turkish, UK Hungarian and Polish markets, while the least efficient were the Ukrainian, Maltese and Estonian. Each of the eighteen markets provides evidence of the time-varying nature of return predictability which is consistent with the adaptive market hypothesis. Lim, Luo, and Kim (2013) show that the three largest US indices have time-varying properties using a rolling window AR and WBAVR test. They argue that markets must go through periods of efficiency and inefficiency.

The purpose of this paper is to extend the literature on the AMH by examining the changing efficiency of the US, UK and Japanese stock markets using tests for independence to determine whether the AMH is appropriate to explain the behaviour of the stock returns of these three countries. We also propose a five-type classification of the behaviour of stock market returns over time. This classification incorporates all possible types of behaviour of stock returns, thus enabling behaviour to be categorised and compared across markets. We contribute to the literature in several ways. First, the data covers a very long time span for three of the most important world markets that have not been previously investigated. Second, this study uses a range of linear and nonlinear tests, thus capturing the main dynamics of stock returns in several dimensions and also reducing the risk that a spurious result from one test may affect the conclusions. Third, this study uses subsample analysis which gives a clear picture of the changing efficiency of the US, UK and Japan, and will not be distorted by long memory as is the case with rolling subsample analysis. Rolling subsample analysis has the major flaw of one extreme event affecting and skewing the results for many subsamples.

The remainder of the paper is organized as follows. The next section explains the methodology of the different statistical tools used to detect departures from the EMH. Section 3 presents the data while Section 4 presents the empirical results. Section 5 summarises the findings and provides conclusions.

2. Methodology

Weak-form market efficiency states that analysis of past prices is futile when predicting prices which mean that stock prices move in a random walk. To examine whether prices follow a random walk, stock returns are examined using five tests for independence. The first three tests examine linear dependence in returns, while the last two tests examine nonlinear dependence in returns. A five-yearly subsample method is favoured to capture the changing efficiency of the three markets. We suggest that stock market return behaviour over subsample periods can be categorised into five types depending on the independence of the returns over time. The five types are: efficient, moving towards efficiency, switching to efficiency/inefficiency, adaptive or inefficient. A market is efficient if returns are independent with no dependence throughout the sample. A market is moving towards efficiency if returns had dependence but over time the dependence in returns has trended to reduce. A market has switched to efficiency/inefficiency if returns were independent (dependent) but become dependent (independent), although this could be evidence of an early stage adaptive market. A market is deemed adaptive if returns have gone through at least three different stages of dependence (e.g. dependent, independent, dependent). Finally, a market is inefficient if it has no independence in returns throughout the sample. Thus this classification incorporates all possible types of returns behaviour. In this paper, for simplicity and clarity, we examine dependency primarily from a statistical viewpoint. As Fama (1965) points out however, dependence from a statistical viewpoint may not be of paramount important for investors, since the magnitude of dependence may be so small that trading on it may be unprofitable given trading costs. The extent to which investors may have been able to profitably trade on the levels of dependence is left beyond the scope of the current paper given the considerable difficulties of estimating realistic historic trading costs over such long investigation periods.

2.1. Linear tests

2.1.1. Autocorrelation Test

The autocorrelation test is a simple and reliable tool for investigating the independence of random variables in a series. If autocorrelations are found, returns are not independent.

Autocorrelations (ρ_k) occur when the covariances and correlations between different disturbances are not all non-zero (i.e. $Cov(\varepsilon_i, \varepsilon_j) = \sigma_{ij}$ for all $i \neq j$, where ε_t is the value of the disturbance in the ith observation).

$$\rho_k = \frac{\gamma_k}{\gamma_0} \tag{1}$$

where γ_1 is the covariance at lag k and γ_0 is the variance. The first order autoregressive process contains values of ε_t lagged by just one period, indicating that the disturbance in period t is influenced by the disturbance in the previous period, ε_{t-1}. If $\rho > 0$ there is positive autocorrelation and if $\rho < 0$ there is negative autocorrelation. The null hypothesis is that $\rho = 0$ and this would imply a random walk process.

2.1.2. Runs test

The runs test is a non-parametric test which also investigates the randomness of a series of stock returns. However, unlike the autocorrelation test, it does not require returns to be normally distributed. The runs test is usually deemed a linear test however it can also detect nonlinearity in a returns series. Thus the results may be somewhat different to the linear autocorrelation test. If an uninterrupted series of data is random, in the runs test the actual number of runs in the series