Topic 2. Predictability of Prices and Market Efficiency

ECON30024 Economics of Finanical Markets

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Outline

1. Introduction
2. Martingales and random walks
3. Efficient Market Hypothesis (EMH)
   - Definition of EMH
   - Testing EMH
   - Different forms of EMH
4. Asset market anomalies
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Required reading: Chap. 3 of Bailey
Supplementary readings: Malkiel (2003) "The Efficient Market Hypothesis and Its Critics" (Readings Online), "Event Studies and Semi-Strong Form EMH Tests" (Week 2 Module)

1. Introduction

- To what extent asset prices can be predicted on the basis of currently available information is a matter of great significance.
- In early 1900s, statisticians noticed that changes in stock prices seem to follow a fair-game pattern, i.e., they are not predictable.
- This has led to the **martingale** and **random walk** models of asset price, which are *reduced form* asset pricing models.
- Testing whether asset prices follow a martingale or random walk provides a way to test the weak form of the **efficient market hypothesis** (EMH).
- The EMH is a general hypothesis regarding the predictability of asset prices.

2. Martingales and random walks

- The martingale model of asset prices
  - In its simplest form, if asset prices (random or stochastic) follow a martingale, then

$$E[p_{t+1}|\Omega_t] = p_t,$$

    where Ω_t denotes the set of information known at date t.
  - Define the rate of return, also random, as

$$r_{t+1} = \frac{p_{t+1} - p_t}{p_t}$$

    Then the martingale model can be rewritten as

$$E[r_{t+1}|\Omega_t] = \frac{E[p_{t+1}|\Omega_t] - p_t}{p_t} = 0$$

– More generally, assume a positive expected rate of return, $\mu > 0$, and modify the model as

$$E[p_{t+1}|\Omega_t] = (1+\mu)p_t, \quad \text{or equivalently}$$

$$E[r_{t+1}|\Omega_t] = \frac{E[p_{t+1}|\Omega_t] - p_t}{p_t} = \mu \tag{1}$$

– Another way to express the martingale model is

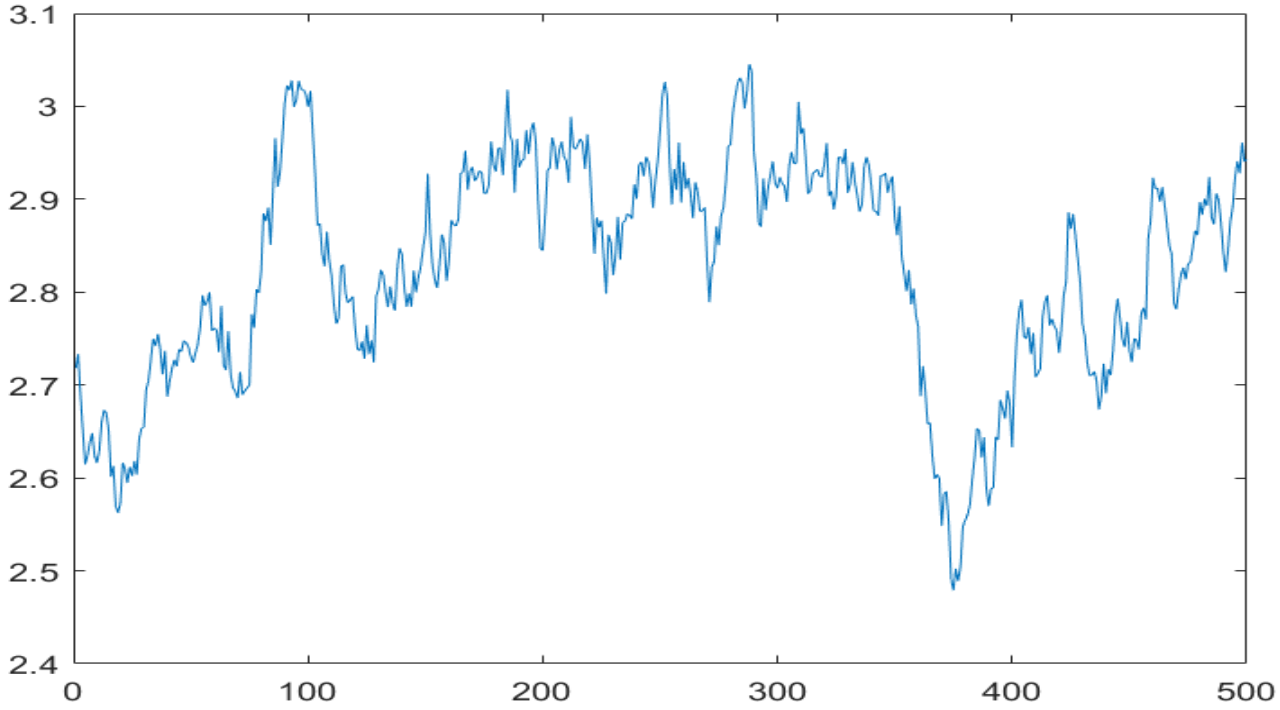
$$r_{t+1} = \mu + \varepsilon_{t+1}, \tag{2}$$

where $\{\varepsilon_t\}$ is a random process satisfying $E[\varepsilon_{t+1}|\Omega_t] = 0$, i.e., ε_t's are mean zero and **uncorrelated** over time

– Equation (2) implies that **asset returns are uncorrelated**.

- The random walk model of asset prices
  - The martingale model (2) places mild restrictions on $\{\varepsilon_t\}$, only restricting ε_t's to be uncorrelated.
  - If we put additional restrictions on $\{\varepsilon_t\}$, then (2) defines a **random walk** model:
    - ε_t's are statistically **independent** of one another
    - ε_t's are statistically independent and identically distributed (IID)
    - ε_t's are IID Normally distributed.
- If asset prices follow a random walk, they must be a martingale, but not vice versa.

- Simulation of asset prices following a random walk (Tutorial 2)



- Empirical testing of a martingale
  - The martingale hypothesis implies that asset returns are uncorrelated:

$$\rho_j \equiv \rho(r_t, r_{t-j}) = \frac{cov(r_t, r_{t-j})}{var(r_t)} = 0,$$

    where ρ_j denotes the jth order autocorrelation of asset returns.
  - Testing of a martingale model of asset prices:
    - Construct asset returns using data on asset prices.
    - Investigating whether the autocorrelations or covariances of asset returns are zeros.

– **Box-Ljung test**: a simple statistical test of whether a group of autocorrelations of a time series are jointly different from zero.

· Testing if ρ_1, ρ_2, ..., ρ_k are jointly different from zero.

· Construct the statistic

$$Q = n(n+2)\sum_{j=1}^{k}\frac{\hat{\rho}_j^2}{n-j} \sim \chi^2(k),$$

where $\hat{\rho}_j$ is the jth order sample autocorrelation.

· The null hypothesis: $Q = 0$

· If it is rejected, asset price is not a martingale (is it a random walk?)

- Empirical testing of a random walk
  - To test the random walk hypothesis, note that

$$r_{t+1} \equiv \frac{p_{t+1} - p_t}{p_t} \approx \log(p_{t+1}) - \log(p_t),$$

  - Recall that a random walk model implies

$$r_{t+1} = \mu + \varepsilon_{t+1},$$

    where ε_t's are independent disturbances with mean 0, then

$$\log(p_{t+1}) - \log(p_t) = \mu + \varepsilon_{t+1} \tag{3}$$

  - The random walk hypothesis implies that **asset returns or changes in asset prices are independent over time**.

– In view of (3), how to test whether asset prices follow a random walk? (Discussion)

- There is a large empirical literature on testing Martingale and random walk models of asset prices.
- Assignment 1 asks you to conduct these tests for some Australian share prices, following Groenewold and Kang (1993).

3. Efficient Market Hypothesis (EMH)

3.1 Definition of EMH

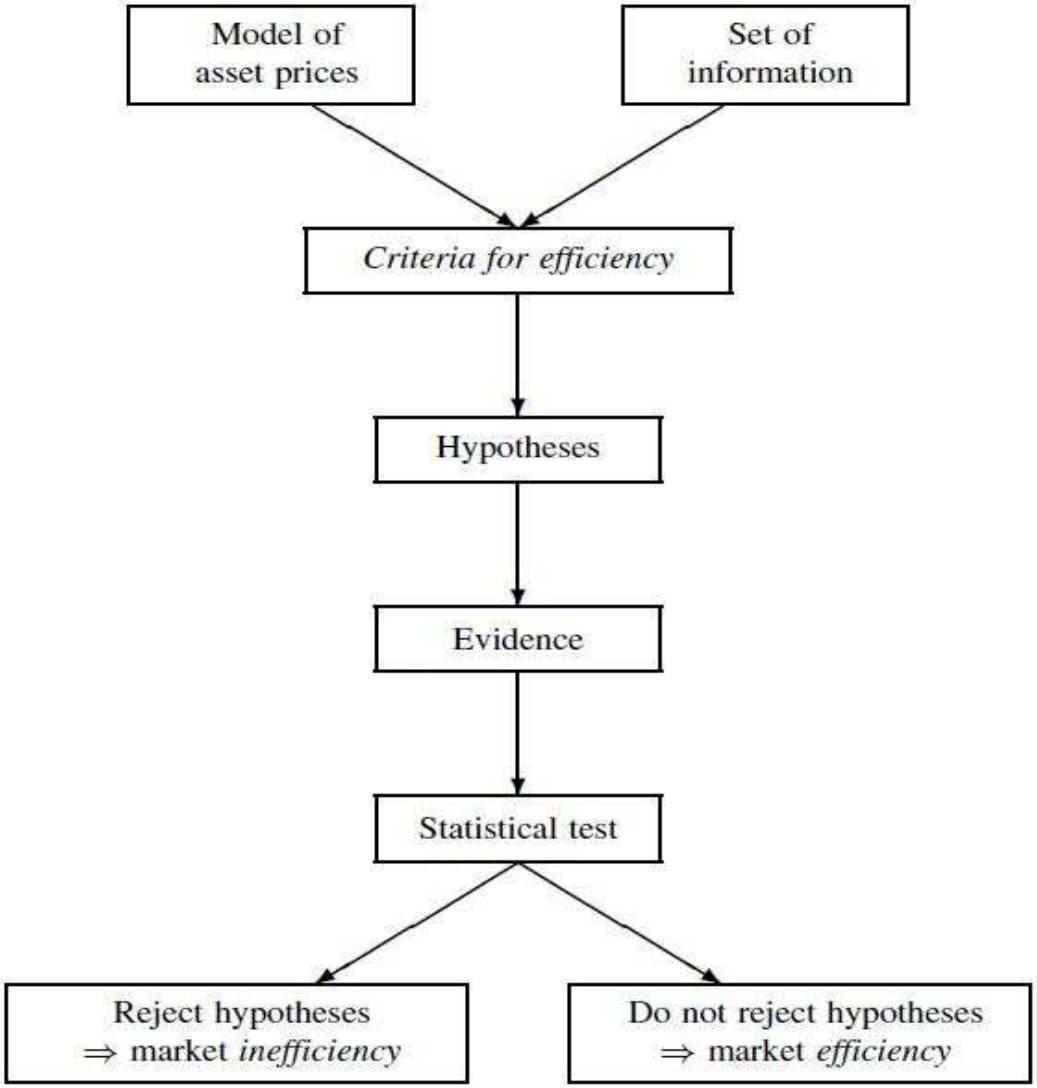
- If asset prices follow a Martingale or random walk, they are not predictable.
- More generally, the EMH asserts that if markets are efficient, asset prices are not predictable.
- A standard definition for EMH: *"A capital market is said to be efficient if it fully and correctly reflects all relevant available information in determining security prices.* (Palgrave 1992)
  - If current and past relevant information is already immediately incorporated into current prices, then only new information, or 'news', should cause changes in prices.
  - But 'news', by definition, is unpredictable, which therefore implies that price changes are unpredictable.

- The definition implies that to test the EMH we first need to specify
  - what constitutes **'relevant'** information?
  - what price patterns **fully and correctly** reflect the set of information?
- That is, testing the EMH requires
  - postulating the set of relevant information–the **information set**, Ω_t
  - **a model/theory** that translates the information into predictions of asset prices, $f_t(\cdot|\Omega_t)$
- Sometimes, we use 'the model' to refer to (Ω_t, f_t).

3.2 Testing EMH

- Conclusions about whether asset markets are efficient or inefficient rely on the **criteria** chosen to characterise efficiency.
- The criteria comes from the **model of asset prices** and **associated information sets**, which together yield predictions on the patterns of asset prices or returns.
- Based on the predictions, testable hypotheses can be formulated.
- The hypothesis is then tested using data collected from the information set and a statistical procedure.
- Figure 3.1 in Bailey illustrates the method for appraising asset market efficiency.

- Figure 3.1. A method for appraising asset market efficiency



- To emphasise,
  - a model is necessary to provide the criteria for distinguishing market efficiency from inefficiency. Even if a model is not formally adopted, it is implicit in the analysis;
  - conclusions must be conditional on the model that provides the criteria for efficiency.
- Testing EMH is actually a **joint test**:

  (i) testing informational efficiency conditional on the model;

  (ii) testing validity of the model used, (Ω_t, f_t).
- Fama refers to the impossibility of separating appraisals of market efficiency from the assumed model of asset prices as the '**joint-hypothesis** problem'.

3.3 Different forms of EMH

- There are three conventional forms or levels of EMH that differ in what information is considered to constitute Ω_t.
- **Weak form efficiency**: the relevant set of information comprises all current and past prices (and rates of return) for the assets being studied.
  - The tests of martingale or random walk hypothesis provide tests for the weak form of EMH.
  - This form of EMH has been tested extensively in the literature.
  - If weak form of EMH holds, **technical analysis** cannot work.

- **Semi-strong form efficiency**: the asset market is efficient relative to all publicly available information.
  - Testing requires specifying what is included in 'public information'.
  - Public information may include asset prices, firm specific information, market/industry information, economy-wide information.
  - Event studies are a popular approach to test semi-strong form efficiency.
  - If it holds, neither **fundamental** nor technical analysis can be used to achieve abnormal returns.

- **Strong form efficiency**: the asset market is efficient relative to all information, public or **private**
  - This form of efficiency is difficult to test empirically, and people hold different views.
  - Many view the strong form efficiency is a rare occurrence, because only if prices do not fully reflect the information, there is an incentive to expend resources in collecting it.
  - A general implication of strong form efficiency: no investors can outperform or beat the market *consistently*; investors could do better by investing in a low-cost, passive portfolio (see video).

4. Asset Market Anomalies

- Asset market anomalies refer to movements in asset prices that seem to violate conventional asset pricing theories.
  - The CAPM is often served as the conventional theory.
- Some well known anomalies that have been identified:
  - Calendar effects (the January effect, the Monday blues, etc.)
  - Weather effect
  - The small firm effect or size effect
  - The high earnings/price ratio effect

  - The high book/market value effect
  - The closed-end mutual fund paradox
  - IPOs and SEOs
  - The momentum effect
  - Mean reversal effect

- Anomalies can disappear once being discovered, and can be unpredictable. Attempting to trade anomalies is risky.
- Do asset market anomalies provide convincing evidence that asset markets are informationally inefficient? (Tutorial 2)

5. Event Studies

- An event study is an empirical analysis that examines the impact of a significant event on the price of an asset or the whole market.
  - The 'event' being studied is a well-defined incident, such as the release of a sales report, the announcement of a merger, a change in interest rate, etc.
  - Associated with the event are observations, for example, on the companies' share prices around the date of the event.
  - Statistical tests are then performed to determine whether the event has significantly impacted asset prices/returns.

- Event studies are widely used in assessments of market efficiency, especially semi-strong form efficiency.
  - By examining the market's reaction to specific events, event studies can provide insights into how efficiently information is incorporated into asset prices.
  - A quick and efficient market reaction would support the EMH, while delayed or incomplete reactions could suggest market inefficiency.
  - Fama(1991): *"Event studies are the cleanest evidence we have on efficiency (the least encumbered by the joint hypothesis problem). "*
- Refer to the reading on event studies for some applications.

Review Questions

- Understand why the martingale model of asset prices implies that future asset price is unpredictable.
- Write down the martingale model in terms of asset prices, and in terms of rate of return on asset prices. What is the assumption on the error term?
- What further assumption on the error term is needed for the asset price to be a random walk?
- Is this statement true? A random walk is a martingale.
- Can you propose a simple method to test whether the price of an asset is a martingale? What's the basic idea underlying this test.
- Understand how the random walk hypothesis can be tested.
- Understand the definition of Efficient Market Hypothesis, in particular, understand the phrases 'fully and correctly reflects' and 'all relevant information'.
- Understand why testing EMH is a joint hypothesis test and its inherent difficulty.

- When a test rejects or fails to reject the EMH, what can you conclude?
- Understand the three different forms of the EMH.
- Have a rough idea on how to test the weak form and the semi-strong form of the EMH.
- Name a few asset market anomalies, and why each of them is regarded as anomalous.
- Do you think the small firm effect provides evidence against the semi-strong form of the EMH?
- What is a event study? Why it is viewed as "cleanest evidence we have on efficiency".