Rational Expectations, the Efficient Market Hypothesis, and the Santa Fe Artificial Stock Market Model

(Substantially modified notes from F. Mishkin, *Money, Banking, and Financial Institutions*, 2004, Chapter 7)

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Topics

- How do economists model the way stock investors form their expectations?

- What does **adaptive expectations** mean?

- What does **rational expectations** mean?

- What is the **Efficient Market Hypothesis (EMH)**?

- What are the implications of the EMH for stock market investing?

- Empirical evidence for and against the EMH in stock markets?

- An Alternative Approach: **The Santa Fe Artificial Stock Market Model**

Alternative Views of Expectation Formation

Adaptive Expectations:

Expectations are formed on the basis of past experiences only, typically as some kind of weighted average of past observations.

EXAMPLE: To form a forecast for the price of IBM stock in 2005, call it $P^e(2005)$, an investor forms a weighted average of the prices he has observed for shares of IBM in 2004, 2003, and 2002:

$$P^e(2005) = .70 \times P(2004) + .20 \times P(2003) + .10 \times P(2002)$$

Rational Expectations: Two Basic Forms

1. Weak-Form Rational Expectations: Whatever information people have, they make optimal use of this information in forming their expectations. (**Note:** *No* restriction placed on information.)

2. Strong-Form Rational Expectations:

   a) People have **access to all relevant available information** about the structure of their environment;

   (**Note**: *Strong* restriction placed on information.)

   b) People make **optimal use of this information** in forming their expectations.

   c) Thus, their expectations will be correct up to unsystematic (unavoidable) errors, e.g., $P^e = P + $ (unavoidable error)

Implications of Strong-Form Rational Expectations

1. If there is a change in the way a variable is determined, then people immediately change their expectations regarding future values of this variable even before seeing any actual changes in this variable.

Example: A change in the rule government uses to set tax rates that will change the amount of taxes people owe each year.

2. Forecasts are not always exactly correct, but forecast errors are not predictable in advance and they average out to zero.

3. Two reasons why expectations can fail to be rational in the strong-form sense:

  a. Investors fail to **use** all available relevant information.

  b. Investors fail to make **optimal** use of all available relevant information.

Efficient Market Hypothesis – Strongest Form:

(1) Expected returns (dividends, etc.) in financial markets are optimal return forecasts using all relevant available info (i.e., investors have strong-form rational expectations).

(2) Security prices in financial markets are determined at market clearing levels (i.e., levels where supply =demand).

(3) Security prices reflect true fundamental (intrinsic) value, meaning there are ***no price bubbles*** on security prices.

Efficient Market Hypothesis – Strongest Form

Example:

Under the EMH, all stock prices are equal to the discounted value of their rationally expected dividend payment streams.

$$P_0 = \sum_{t=1}^{\infty} \frac{D_t^e}{(1+k_e)^t}$$

Implications of EMH for Investing

1. Published reports of financial analysts not very valuable

2. Should be skeptical of hot tips

3. Security prices might fall on good news

4. Prescription for investors:

    a. Shouldn't try to outguess market.
    b. Therefore, buy and hold.
    c. Diversify with no-load mutual fund.

Evidence on EMH in Stock Markets

Early Favorable Empirical Evidence (1970-1983):

1. Investment analysts and mutual funds do not persistently beat the market (e.g., the average return on the S&P 500)

2. Technical analysis (predicting future prices on the basis of past price patterns) does not persistently beat the market.

3. Stock prices appear to reflect publicly available information: *anticipated* announcements do not appear to affect stock prices

4. Departures of stock prices from fundamental value do not appear to be predictable, i.e.,

    $$P_{t+1} + Div_{t+1} \approx (1+k_e) \times P_t + \text{(unsystematic mean-0 error)}$$

Evidence on EMH in Stock Markets

Unfavorable Empirical Evidence ("Anomalies") Since 1983:

1. Small-firm effect: Small firms have abnormally high returns

2. January effect: Abnormal price rise from December to January (small firms)

3. Market overreaction to news announcements

4. Excessive stock price volatility relative to fluctuations in fundamental value

5. Mean reversion (low returns today $\rightarrow$ higher returns in future, and vice versa)

6. New information is not always immediately incorporated into stock prices

Summary Overview: EMH might be a reasonable starting point for understanding stock markets, but it is not the whole story

Other Critiques of the EMH (Batten, Chapter 7)

- Real-world investors do not have access to "all relevant available information." (p. 211)

- Even if investors have same information, differences in psychological make-up can lead to systematic differences in expectations. (p. 211)

- Fundamental approach to stock pricing (i.e., the EMH in strong form) trivializes demand side of the equation -- it assumes stock prices determined by "intrinsic value" (supply side) alone. (p. 212)

- EMH is essentially a static theory that ignores positive feedback loops. (pp. 229-231)

Other Critiques of the EMH…Continued (Batten, Chapter 7)

- At the heart of the dynamics in financial markets is a process of co-evolutionary learning (p. 235)

- "What makes the participants' understanding imperfect is that their thinking affects the very situation to which it applies." (p. 235)

- "Even the shapes of supply and demand curves cannot be taken as independently given, because both are built on the participants' expectations (or hypotheses) about events that are, in turn, shaped collectively by their own expectations." (p. 234)

Other Critiques of the EMH…Continued (Batten, Chapter 7)

- Following theory expounded by George Soros, Batten argues that participants' **attempts to understand the world** have an impact on **actual outcomes**. (p. 235)

- These two processes interfere with each other. (p.235)

- Soros refers to this particular kind of positive feedback process as "*reflexivity*." (p. 235)

- Reflexivity tends to produce a never-ending process of change in **both** expectations **and** outcomes. (pp. 235-236)

Alternative Approach: Agent-Based Models
(Batten, Chapter 7)

- "Why not view the stock market as a diverse collection of beliefs, expectations, and mental models?" (p. 242)

- **Example:** Santa Fe Artificial Stock Market Model

- (Arthur et al.) created an artificial stock market on the computer, inhabited by `investors' who are individual, artificially intelligent programs that can reason inductively. … (The traders) are constantly testing and discarding expectational hypotheses… Some investors keep many such models in mind, others may retain only one at a time." (p. 242)

Alternative Approach: Agent-Based Models
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- "The learning process in this silicon world comes from two sources: discovering `new' expectational models, and identifying the ones that perform best from among the current set." (p. 243)

- "Prices form endogenously from the bids and offers of the silicon agents, and thus ultimately from their beliefs. (p. 243)

- "A key aspect of (such models is) their internal dynamics. Expectations come and go in an ocean of beliefs that form a coevolving ecology." (p. 243)

Alternative Approach: Agent-Based Models
(Batten, Chapter 7)

- **In the words of W. Brian Arthur:**

"As the dial of heterogeneity of initial beliefs is turned up, the market undergoes a phase transition and `comes to life.' It develops a rich psychology and displays phenomena regarded as anomalies in the standard theory but observed in real markets. …

We could therefore name the two regimes or phases *simple* and *complex*. There's growing evidence suggesting that actual financial markets live within the complex regime."

(W. B. Arthur, *Complexity,* Vol.1, pp. 20-25)