EC371 Economic Analysis of Asset Prices

Mock Exam

Answer Guidelines

Section A Answer TEN questions.

1. An asset will pay a dividend of \$11 at date $t+1$ at which date its market value will be \$77 (with certainty). The risk-free interest rate between t and $t+1$ equals 10%. Calculate the asset price at t, assuming markets are frictionless.

   Answer guidelines:

   In a frictionless market, it would be possible to make arbitrage profits (unlimited payoff, with zero outlay) unless the risk-free interest rate equals the rate of return on the asset. Hence, the asset price, p, must satisfy:

$$\begin{aligned} r = 0.10 &= \frac{77+11-p}{p} \\ 1+r = 1.10 &= \frac{77+11}{p} \\ p &= \frac{88}{1.10} \\ p &= 80 \end{aligned}$$

   Hence, in the absence of arbitrage opportunities, the asset price must equal $\$80$.

2. Explain, using an example, the meaning of 'buying shares on margin'.

   Answer guidelines:

   When an investor buys shares on margin, only a proportion of the purchase value is paid up-front (the margin). Eventually, the balance must be paid before the shares are delivered to the investor, or the shares are sold.

   For example, suppose that an investor purchases 100 shares at price $£5$ per share, paying an initial margin of 50% to a broker. This means that the investor pays $£250 = 0.5 \times 100 \times 5$ into a margin account.

   In the event that the shares are sold at a price greater than $£5$, the investor gains, without having had to pay the full purchase price.

   In the event that the share prices fall, the margin falls, e.g. if the price falls to $£4$, the margin falls to $0.375 = (400-250)/400$, i.e. 37.5%. If this is below the *maintenance margin*, the investor is required to pay funds into the margin account, typically to restore the margin to its initial proportion. For example, if the maintenance margin is 40%, the investor would be required to pay an additional $£50$ into the account, thus restoring the margin to $0.50 = (400-200)/(400)$.

3. What is meant by the 'Efficient Markets Hypothesis' for stock market prices?

   Answer guidelines:

   The 'Efficient Markets Hypothesis' (EMH) is usually interpreted to mean that asset prices fully reflect all available information. The typical justification for the EMH is that, if it did not hold, then investors would perceive the opportunity to gain from the information: their attempts to realise this gain would then force prices to change to eliminate the gain so that EMH holds.

   Stated this way, the EMH is incomplete because (a) it does not explain what 'fully reflects' means (this requires a model of asset prices to express 'efficiency'), and (b) it does not stipulate which 'information' is available (and who possesses the information).

   Sometimes it is assumed that the information relevant for the EMH is restricted to 'fundamental' information. But this resolves nothing unless fundamental information is distinguished from non-fundamental information. Even if such a distinction is provided, the issue of the model used to identify the meaning of 'fully reflects' remains open.

   In summary, the EMH is a highly ambiguous concept, only of merit if its vaguenesses are resolved in some way.

4. Describe, with an example, how an 'anomaly' can be used in testing asset market efficiency.

   Answer guidelines:

   An anomaly refers to a phenomenon contrary to 'conventional wisdom'. If 'conventional wisdom' is understood as a benchmark (i.e. prediction) corresponding to a model that expresses asset market efficiency, then the anomaly can be interpreted as evidence of market inefficiency.

   For example, suppose that conventional wisdom is expressed by the CAPM. The CAPM predicts that the excess return on an asset proportional to the excess return on the market: $\mu_j - r_0 = (\mu_M - r_0)\beta_j)$, where μ_j is the expected rate of return on asset j, r_0 is the risk-free interest rate, μ_M is the expected rate of return on the market portfolio, and β_j is beta-coefficient for asset j.

   Suppose that the 'anomaly' is that companies with a 'small' capitalization are observed to have higher than expected excess rates of return, where the CAPM prediction is used as the benchmark for what is 'higher than expected'. Then the anomaly is evidence of asset market inefficiency (conditional on the CAPM benchmark to express efficiency).

5. State and briefly interpret the 'First Mutual Fund Theorem' in mean-variance analysis (when all assets are risky).

   Answer guidelines:

   The theorem refers to portfolios of *risky assets only*, chosen to minimise the port-

folio's rate of return variance ('risk') for any given level of the portfolio's expected return. These are known as 'frontier portfolios'.

The theorem states that *any* frontier portfolio can be formed as a portfolio of two composite assets ('mutual funds') that are themselves frontier portfolios. The two composite assets can be any frontier portfolios (that are not identical to one another).

The theorem means that mean-variance portfolio selection with any number of risky assets can be interpreted as if the selection is made from exactly two assets, thus greatly simplifying the analysis.

6. Explain, using an example, the meaning of 'Risk Adjusted Performance' for an asset.

   Answer guidelines:

   Suppose that an asset's expected rate of return is given by $\mu_j = 0.17$, its standard deviation of return is given by $\sigma = 0.3$ and the risk-free interest rate is $r_0 = 0.05$. Then its *Sharpe ratio* equals $s_j = 0.4 = (\mu_j - r_0)/\sigma_j = (0.17 - 0.05)/0.3$.

   The asset's Risk Adjusted Performance is its expected rate of return for some benchmark level of standard deviation of return (risk), holding given the Sharpe ratio. Suppose that the benchmark risk is $\sigma_B = 0.2$. Then the asset's RAP equals $0.13 = 0.05 + 0.2 \times 0.4$ (in general RAP $= r_0 + \sigma_B \times s_j$).

   Thus the RAP for the asset is lower than its expected rate of return because the benchmark risk (σ_B) is lower than the asset's risk (as measured by σ_j).

7. The expected rate of return on an asset is given by $\mu_j = 12\%$, while the risk-free interest rate is $r_0 = 4\%$. The asset's standard deviation of return is $\sigma_j = 0.6$, while for the market portfolio $\sigma_M = 0.4$. The correlation between the asset's return and the market return is: $\rho_{jM} = 0.8$. Define and calculate the beta-coefficient, β_j, for asset j.

   Answer guidelines:

   The beta-coefficient β_j is defined as:

   $$\beta_j = \rho_{jM} \frac{\sigma_j}{\sigma_M}$$

   Hence, in this case $\beta_j = 1.2 = 0.8 \times 0.6/0.4$.

8. Define and interpret the 'Capital Market Line' in the Capital Asset Pricing Model.

   Answer guidelines:

   The 'Capital Market Line' (CML) characterises the set of mean-variance efficient portfolios in CAPM equilibrium. The equation of the line, when a risk-free asset is present, is given by the set of μ_E, σ_E that satisfy:

   $$\frac{\mu_E - r_0}{\sigma_E} = \frac{\mu_M - r_0}{\sigma_M}$$

where μ_E is the expected rate of return on an efficient portfolio, σ_E is the standard deviation of the rate of return on an efficient portfolio, μ_M is the expected rate of return on the market portfolio, σ_M is the standard deviation of the rate of return on the market portfolio, and r_0 is the risk-free interest rate.

Thus the CML can be written: $\mu_E = r_0 + \dfrac{\mu_M - r_0}{\sigma_M}\sigma_E$. For all mean-variance efficient portfolios, $\rho_{EM} = +1$, i.e. there is perfect positive correlation with the rate of return on the market portfolio.

9. Formally define an 'arbitrage opportunity' when asset returns are uncertain.

   Answer guidelines:

   An arbitrage portfolio is defined by a portfolio requiring zero initial outlay, which has an non-negative payoff in all states of the world. An arbitrage opportunity is a set of asset prices such that an arbitrage portfolio exists, with a positive payoff in at least one state.

   Formally, an arbitrage portfolio, $x_1,\ x_2,\ \ldots,\ x_n$, satisfies:

   1. *Zero initial outlay*: $p_1x_1 + p_1x_2 + \cdots + p_nx_n = 0$, with not all $x_j = 0$ for $j = 1,\ 2, \ldots,\ n$.
   2. *Risk free*: $v_{k1}x_1 + v_{k2}x_2 + \cdots + v_{kn}x_n \geqq 0$, for every state $k = 1,\ 2,\ \ldots,\ \ell$,

   where x_j denotes the quantity of asset j, p_j is the price of asset j, and v_{kj} is the payoff of asset j in state k.

   An arbitrage opportunity occurs if for at least one state, h:
   $v_{h1}x_1 + v_{h2}x_2 + \cdots + v_{hn}x_n > 0$, where $x_1,\ x_2,\ \ldots,\ x_n$ is an arbitrage portfolio.

10. State and interpret the prediction of the Arbitrage Pricing Theory (APT) for a one-factor model of asset returns.

    Answer guidelines:

    The prediction of the APT for a one-factor model is:

    $$\mu_j = \lambda_0 + \lambda_1 b_{j1} \qquad \text{for all assets } j = 1,\ 2, \ldots,\ n$$

    where μ_j is the expected rate of return on asset j, b_{j1} is the factor loading of asset j, and λ_0, λ_1 are parameters that are the same for all assets. The factor loading, b_{j1} is defined by:

    $$r_j = b_{j0} + b_{j1}F_1 + \varepsilon_j, \qquad j = 1,\ 2, \ldots,\ n$$

    where r_j is the rate of return on asset j, F_1 is the value of the factor and ε_j is an unobserved random error, for which $\mathrm{E}[\varepsilon_j \mid F_1] = 0$.

    The parameter λ_1 is interpreted as the risk premium associated with the factor, where λ_0 is the risk-free interest rate.

11. What is a 'Ponzi scheme'?

    Answer guidelines:

    A Ponzi scheme is an investment plan (typically a 'scam') that offers high rates of return, generated by later contributions to the plan. The payoff of the initial investors is made from the contributions of the second 'generation', who receive their payoffs from the third 'generation', and so on.

    The success of a Ponzi scheme requires increasing contributions to the scheme. As soon as the rate of growth slows, there is insufficient funds to fulfil the promised payoffs: the scheme then collapses.

12. Explain what is meant by a 'quote driven' (or 'dealer') form of market organisation.

    Answer guidelines:

    Dealers trade securities with 'public investors' (those investors who acquire securities to hold, rather than as part of the business of trading) and other dealers. Dealers typically quote 'bid' and 'ask' prices, at which they undertake to buy and sell, respectively. Sometimes they also stipulate the volume of each trade that they will accept. Public investors then select a dealer with whom to trade.

    A 'quote driven' market, thus requires a method of disseminating the quotes of participating dealers, together with procedures for executing and settling the agreed trades.

Section B Answer one question.

13. Answer *both* parts (a) and (b) of this question.

(a) "A capital market is said to be efficient if it fully and correctly reflects all relevant information in determining security prices." (*New Palgrave Dictionary of Money and Finance*)

(i) [20 marks] Describe a procedure for assessing the informational efficiency of a capital market in the context of this statement.
Answer guidelines:
Answers are normally based on the scheme in figure 1, below.

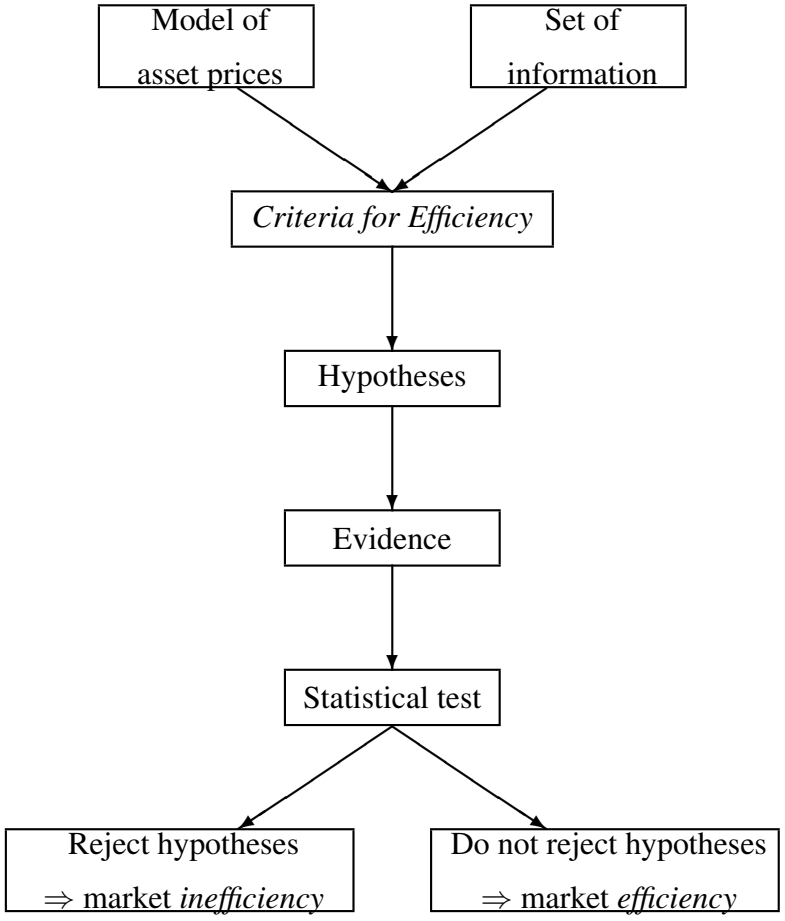

Figure 1: A Method for Appraising Asset Market Efficiency

- Answers will explain that it is necessary to specify what is meant by "all relevant information" in characterising information. Some will describe 'weak form', 'semi-strong' and 'strong' form efficiency – this is relevant inasmuch as the link is made to the need to specify the bounds of relevant information.

- Upper-second/first class answers will emphasise that "fully and correctly reflects" implies that it is necessary to postulate a model of asset prices in order to provide the necessary benchmark.
- Answers may include an example, typically the random walk model. While not strictly necessary credit should be given as appropriate. Answers that describe the random walk without placing it in the context of a broader methodology, deserve at most 12/20 marks.
- Having postulated a model and information set, answers will outline (normally without any derivations, which are not expected) that the predictions of the model provide the criteria for efficiency.
- It is then necessary to apply the predictions to one or more sets of data.
- Statistical tests are then applied in order to test the predictions of the model. Rejection of the hypothesis implies evidence of inefficiency. Non-rejection is evidence consistent with efficiency.
- Upper-second/first class answers will emphasise that the results depend on the model, information set and data chosen.

(ii) [10 marks] What are the difficulties and potential pitfalls in applying the procedure you have described?
Answer guidelines:

- Different models may, generally will, suggest different criteria for efficiency, even with the same information set.
- Different information sets may, generally will, suggest different criteria for efficiency, even with the same model.
- Different datasets may yield contradictory results.
- Results are subject to the common type-I and type-II errors of statistical decision making.

(b) [20 marks] How would you assess the claim that "stock prices are too volatile for compatibility with asset market efficiency"?

Answer guidelines:

- Most answers will be based on Shiller's analysis of asset price volatility.
- Shiller assumes the existence of an 'ex post rational' price, p_t^*, such that

$$p_t^* = p_t + u_t \tag{1}$$

where p_t is the observed market price and u_t is an unobserved forecast error, such that $\mathrm{E}[u_t \mid p_t] = 0$.

- The ex post rational price is not observed. Shiller estimates its value recursively working back from a base year, assuming that dividends are perfectly

foreseen. For example:

$$\begin{aligned} p^*_{2002} &= \frac{1}{(1+r)}(d_{2003} + p^*_{2003}) \\ p^*_{2001} &= \frac{1}{(1+r)}(d_{2002} + p^*_{2002}) \\ p^*_{2000} &= \frac{1}{(1+r)}(d_{2001} + p^*_{2001}) \\ \vdots &\quad \vdots \end{aligned} \tag{2}$$

where p^*_{2003} is taken as given and d_t corresponds to dividends observed at date t.

- It follows from the property of the forecast error that the model predicts that the variance of p^*_t exceeds the variance of p_t: this is Shiller's criterion for efficiency.
- Shiller (and most others, too) find evidence that contradicts the prediction by a wide margin, hence concluding that asset prices are too volatile to be consistent with efficiency.
- Upper-second/first class answers will discuss criticisms of Shiller's analysis, in particular whether the ex post rational price provides an appropriate criterion for efficiency. Some may mention statistical problems in Shiller's treatment of the data: this is not obligatory, even for a first class answer.

14. In an economy with only two possible states of the world and three assets, the payoffs for the assets in each state and the market prices of the assets are given by:

	Asset A	Asset B	Asset C
State 1	7	12	2
State 2	5	0	10
Price	p_A	6	4

Answer *all* parts (a) – (d) of this question.

(a) [20 marks] Define the terms *arbitrage portfolio*, *arbitrage opportunity* and the *arbitrage principle*. Hence, using the information above, obtain the price p_A that satisfies the arbitrage principle.

Answer guidelines:

An **arbitrage portfolio** is defined by:

1. The portfolio requires *zero initial outlay*: some assets are held in positive amounts, some in negative amounts and, perhaps, some in zero amounts. (Only portfolios that contain a positive or a negative amount of at least one asset are considered, i.e. all portfolios are assumed to be non-vacuous, or non-trivial.)

2. The portfolio is *risk free*: the payoff on the portfolio in every state must be either positive or zero. It must not be positive in some states and negative in others.

Formally, an **arbitrage portfolio**, $x_1,\ x_2,\ \ldots,\ x_n$, satisfies:

1. *Zero initial outlay*: $p_1x_1 + p_1x_2 + \cdots + p_nx_n = 0$, with not all $x_j = 0$ for $j = 1,\ 2, \ldots,\ n$.
2. *Risk free*: $v_{k1}x_1 + v_{k2}x_2 + \cdots + v_{kn}x_n \geqq 0$, for every state $k = 1,\ 2,\ \ldots,\ \ell$,

where x_j denotes the quantity of asset j, p_j is the price of asset j, and v_{kj} is the payoff of asset j in state k.

Define the payoff for portfolio $\boldsymbol{x}$ in state k as

$$v(\boldsymbol{x},\ k) \equiv v_{k1}x_1 + v_{k2}x_2 + \cdots + v_{kn}x_n$$

Thus, if $\boldsymbol{x}$ is an arbitrage portfolio, it involves zero initial outlay and $v(\boldsymbol{x},\ k) \geqq 0$ for every state k.

Arbitrage opportunity: a set of asset prices such that an arbitrage portfolio exists, *and* $v(\boldsymbol{x},\ k) > 0$ for at least one k. That is, a strictly *positive* payoff occurs in one or more states and a loss in no state.

Arbitrage principle: the arbitrage principle asserts that arbitrage opportunities are absent. Arbitrage opportunities are absent when a set of asset prices for which exactly one of the following two conditions holds:

(a) For every arbitrage portfolio, $v(\boldsymbol{x},\ k) = 0$ in every state.

(b) No arbitrage portfolio exists. That is, for every portfolio requiring zero initial outlay, $v(\boldsymbol{x},\ k) \geqq 0$ for some state(s) and $v(\boldsymbol{x},\ k) < 0$ for some state(s).

Construct an arbitrage portfolio $x_A,\ x_B,\ x_C$ that has a zero payoff in each state:

Outlay: $p_Ax_A + 6x_B + 4x_C = 0$.

Payoff in state 1: $7x_A + 12x_B + 2x_C = 0$

Payoff in state 2: $5x_A + 0x_B + 10x_C = 0$

From the payoffs: $x_A/x_C = -2$ and $x_B/x_C = 1$. Hence, $p_A = 5$.

(b) [10 marks] Define the term *state prices*. What is their relationship to the arbitrage principle? Obtain the state prices using the information above.

Answer guidelines:

A state price, q_k, is defined to be the price of an asset that has a payoff of one unit of wealth in state k and zero in every other state.

The arbitrage principle is equivalent to the existence of positive state prices, $q_1,\ q_2,\ \ldots,\ q_\ell$ such that

$$p_j = q_1v_{1j} + q_2v_{2j} + \cdots + q_\ell v_{\ell j}, \qquad j = 1,\ 2,\ \ldots,\ n \tag{3}$$

In this example:

$$\begin{aligned} p_A &= 5 = 7q_1 + 5q_2 \\ p_B &= 6 = 12q_1 + 0q_2 \\ p_C &= 4 = 2q_1 + 10q_2 \end{aligned}$$

Hence, $q_1 = 0.5$, $q_2 = 0.3$.

(c) [15 marks] In the context of the arbitrage principle, define the terms *Risk Neutral Valuation Relationship* (RNVR) and *martingale probabilities*. Obtain the martingale probabilities and show that the RNVR is satisfied using the information above. Comment on the interpretation of the martingale probabilities.

Answer guidelines:

The Risk Neutral Valuation Relationship (RNVR) states that the arbitrage principle is equivalent to the existence of:

1. a risk-free rate of return, r_0, with associated discount factor, $\delta \equiv 1/(1+r_0)$, and
2. probabilities, $\pi_1, \pi_2, \ldots, \pi_\ell$, one for each state, such that

$$p_j = \delta \mathrm{E}^*[v_j] \qquad j = 1, 2, \ldots, n \tag{4}$$

The symbol v_j denotes the list of payoffs, one for each state, for asset j. (In this context, v_j is a 'random variable': a set of outcomes, each with its associated probability.) The expectation, $\mathrm{E}^*[v_j]$, is the payoff of asset j in each state weighted by the probability of that state and summed over the states:

$$\mathrm{E}^*[v_j] \equiv \pi_1 v_{1j} + \pi_2 v_{2j} + \cdots + \pi_\ell v_{\ell j} \tag{5}$$

The asterisk * superscript appears as a reminder that the probabilities in (5) are purely artificial: they are an *implication* of the proposition and need not correspond to any investor's beliefs.

In this example:

$$\begin{aligned} p_A &= 5 = \delta[7\pi + 5(1-\pi)] \\ p_B &= 6 = \delta[12\pi + 0(1-\pi)] \\ p_C &= 4 = \delta[2\pi + 10(1-\pi)] \end{aligned}$$

Hence, $\delta = 4/5 = 0.8$ and $\pi = 5/8 = 0.625$.

(d) [5 marks] Suppose a fourth asset, D, with payoffs, 6 and 20 in states 1 and 2, respectively, is observed to have a market price $p_D = 8$. What inferences could you make in the context of the above information?

Answer guidelines:

Predict the market price using either the state prices or the RNVR:

$$0.5 \times 6 + 0.3 \times 20 = 9 > 8 = p_D$$

Implication: the arbitrage principle is not satisfied, there exists an arbitrage opportunity.

15. Answer *all* parts (a), (b) and (c) of this question.

(a) [17 marks] Explain briefly the *Expected Utility Hypothesis* in the context of portfolio selection.

Answer guidelines:

- Answers should explain that the essential implication of the EUH is that the investor's objective function can be written in the form of the expectation of a von Neumann-Morgenstern utility function. The von Neumann-Morgenstern utility function expresses the investor's attitude to risk, and depends on terminal wealth. The probabilities with respect to which the expectation is taken express the investor's 'beliefs' about which state of the world will occur.
- First/2.1 answers will also outline axioms which imply the existence of a von Neumann-Morgenstern utility. A detailed statement of the axioms is neither expected nor required. (Answers will *not* include a formal derivation of the von Neumann-Morgenstern utility function.)
- First/2.1 answers will also include a brief statement of the portfolio optimization problem, i.e., to choose a portfolio, $x_1,\ x_2,\ \ldots\ x_n$, to maximize: $\mathcal{U} = \pi_1 u(W_1) + \pi_2 u(W_2) + \cdots + \pi_\ell u(W_\ell)$ subject to: $p_1 x_1 + p_2 x_2 + \cdots + p_n x_n = A$ where: $W_k = v_{k1}x_1 + v_{k2}x_2 + \cdots + v_{kn}x_n$, where v_{kj} is the payoff to security j in state k.

(b) [17 marks] What is the *Fundamental Valuation Relationship* (FVR)? Explain how it can be obtained. What is the purpose of the FVR in portfolio theory?

Answer guidelines:

- The FVR is a necessary condition that must be satisfied at the maximum of expected utility. It is the set of first order conditions for maximizing EU with respect to $x_1,\ x_2,\ \ldots\ x_n$.
- In its most general form the FVR is written as

$$\text{*Fundamental Valuation Relationship*:} \qquad \mathrm{E}[(1+r_j)H] = 1, \qquad j = 1,\ 2,\ \ldots,\ n \tag{6}$$

  where H is a 'random variable' in the sense that it varies across states.
- Consider the one-period, static portfolio problem in which the investor seeks to maximize the expected utility of wealth. Suppose that the investor devotes one additional unit of wealth to asset j. The payoff is $(1 + r_j)$ and the increment to utility is $(1 + r_j)u'(W)$. This varies across states, the increment to *expected* utility being $\mathrm{E}[(1 + r_j)u'(W)]$. (In words: weight the utility increment in each state by the state's probability and sum over the states.)

  At a maximum of expected utility it is necessary that the expected utility increment is the same, say λ, for each asset, so that

$$\mathrm{E}[(1 + r_j)u'(W)] = \lambda, \qquad j = 1,\ 2,\ \ldots,\ n \tag{7}$$

If (7) does not hold, then expected utility can be increased by shifting wealth from those assets with low values of $\mathrm{E}[(1 + r_j)u'(W)]$ to those with high values. Only when equality holds for every asset can expected utility be at a maximum.

At a maximum of expected utility, the expected *marginal* utility of wealth must equal the increment to expected utility from a small change in the holding of any asset; otherwise expected utility is not at a maximum.

Finally, divide both sides of (7) by λ and observe that the FVR holds with $H \equiv u'(W)/\lambda$.

- Purpose of the FVR: if the second order condition is satisfied (essentially declining marginal utility of wealth), then, in principle, the FVR can be solved to obtain the optimum portfolio. In practice, the FVR provides testable predictions about the composition of portfolios and asset prices consistent with the EUH.

(c) [16 marks] Outline the *Equity Premium Puzzle*, being careful to identify the role of the FVR in the puzzle.

Answer guidelines:

- The puzzle is commonly stated by asserting that the equity premium — the excess of the average return on equity above a low-risk rate — is too large to be explained by the EUH when applied in an intertemporal context.
- In the intertemporal context, the FVR becomes

$$\mathrm{E}_t \left[(1 + r_{j,t+1}) \delta \frac{u'(C_{t+1})}{u'(C_t)} \right] = 1, \qquad j = 1, 2, \ldots, n. \tag{8}$$

- Three specific assumptions are typically invoked in studies of the EPP:
  1. *Beliefs and preferences.* Every investor is assumed to have additive intertemporal preferences with an iso-elastic utility function, $u(C) = C^{1-\gamma}/(1-\gamma)$. Differentiation and substitution into $H = \delta u'(C_{t+1})/u'(C_t)$ results in: $H = \delta(C_{t+1}/C_t)^{-\gamma}$ (where the time subscript on H is omitted for simplicity).
  2. *Complete Markets.* Markets are *complete* in the sense that for each state, there exists an asset with a payoff of 1 unit of wealth if that state occurs and zero if any other state occurs.
  3. *Frictionless Markets.*

     The EPP can be obtained by manipulating the FVR:

$$\mathrm{E}\left[(1 + r_j)H\right] = 1 \tag{9}$$

Choose two assets, equity, with rate of return r_e and bonds with rate of return, r_b. Hence:

$$\begin{aligned} \mathrm{E}[(1 + r_e)H] &= 1 \\ \mathrm{E}[(1 + r_b)H] &= 1 \qquad (10) \\ \mathrm{E}[(r_e - r_b)H] &= 0 \qquad (11) \end{aligned}$$

Now, under the assumption of iso-elastic utility in the intertemporal consumption and portfolio selection model, (11) becomes

$$\mathrm{E}[(r_e - r_b)(1+c)^{-\gamma}] = 0, \tag{12}$$

where $c \equiv (C_{t+1}/C_t) - 1$ denotes the rate of growth of consumption. Notice that δ can be factored out of the expectation and eliminated from (12).

The EPP asserts that *the value of γ needed to satisfy (12) in the data is much larger than values of γ estimated in other contexts* (which focus on measuring γ as an index of risk aversion). While there is no consensus about the exact magnitude of γ obtained in these other models, many studies favour a value less than 3. This is much lower than estimates obtained from using sample averages to represent expected returns, and the average rate of growth per capita consumption for c, in (12). Kocherlakota (1996), for example, finds that a γ of at least 8.5 is needed to satisfy the sample variant of (12).

End of Paper

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