Climate Risk and Asset Pricing

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Chapter 1

States of the World and Asset Pricing

Assets give a *payoff* x_{t+1}. In our focus on stocks, $x_{t+1} = p_{t+1} + d_{t+1}$, where p_{t+1} is the price of the stock at time $t+1$ and d_{t+1} is the dividend paid at time $t+1$. x_{t+1} is a random variable, like a coin-flip - we don't know at t what it will be at $t+1$. But we can assign probabilities to the possible outcomes of x_{t+1}. We can think of the *randomness* of x_{t+1} as being due to the randomness of the *state of the world* at $t+1$. x_{t+1} takes on different values in different *states of the world*. We have:

$$E(x_{t+1}) = \sum_s \pi(s)x(s) \tag{1.1}$$

where $E(x_{t+1})$ is the expected value of x_{t+1}, $\pi(s)$ is the probability of state s, and $x(s)$ is the value of x_{t+1} in state s.

The question we are trying to answer here is: what is the price or value p_t of the payoff x_{t+1} at time t?

1.1 Asset Pricing Formula

1.2 Discount Factor

Example X
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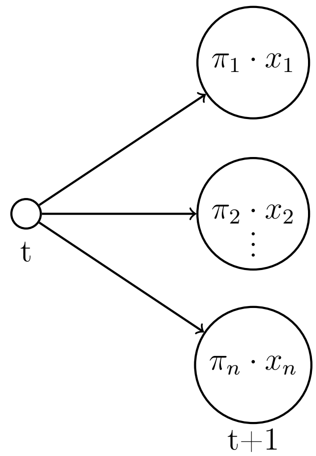

Figure 1.1: States of the world at time $t+1$

1.3 Risk Valuation

To apply what we have learned so far to risk valuation, we can start from the definition of the covariance:

$$\mathrm{Cov}(m,x) = E(mx) - E(m)E(x) \tag{1.2}$$

Thus,

$$p = E(mx) = \mathrm{Cov}(m,x) + E(m)E(x) \tag{1.3}$$

$$p = \frac{1}{R^f}E(x) + \mathrm{Cov}(m,x) \tag{1.4}$$

with the approximation

$$m_{t+1} \approx 1 - \delta - \gamma \Delta c_{t+1} \tag{1.5}$$

we have

$$p_t^i \approx \frac{1}{R^f}E(x_{t+1}^i) + \mathrm{Cov}(x_{t+1}^i, \Delta c_{t+1}) \tag{1.6}$$

That is, the price is lower if the asset do well when consumption is low, and vice versa. Prices are higher for assets that provide insurance against consumption risks. Prices are low for assets that, if you buy them, make your consumption more risky.

In risk valuation, the covariance term really matters. The same m and the same x can have different prices depending on the covariance between m and x.

Example 1

Suppose there are two states u and d tomorrow, with probability 1/2 each. In state u, consumption is high, and in state d, consumption is low.

$$p_t = E(m, x) = \frac{1}{2} m_u x_u + \frac{1}{2} m_d x_d \tag{1.7}$$

Suppose x pays off well in good times if $x_u = 2$ and $x_d = 1$. Suppose also that $m_u = 0.5$ and $m_d = 1$. Then,

$$p_t = \frac{1}{2} \times 0.5 \times 2 + \frac{1}{2} \times 1 \times 1 = 1 \tag{1.8}$$

Now suppose we keep the same volatility but x pays off well in bad times and badly in good times, with $x_u = 1$ and $x_d = 2$.
Then,

$$p_t = \frac{1}{2} \times 0.5 \times 1 + \frac{1}{2} \times 1 \times 2 = 1.25 \tag{1.9}$$

The payoff is worth more in the second case because it pays off more in bad times, that is when m is high (hungry) rather than m is low (full). m acts like a price: it says that payoffs delivered in the bad state of nature d worth more than payoffs delivered in the good state of nature u.

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