

## UNIVERSITY OF TEXAS AT AUSTIN

Quiz #4

The log-normal distribution. Log-normal stock prices.

**Problem 4.1.** (5 points) *Source: Problem 18.6 in McDonald.*

Let  $X \sim N(\text{mean} = 2, \text{variance} = 5)$ .

- (i) (3 points) Find  $\mathbb{E}[e^X]$ .
- (ii) (2 points) Find the median of  $e^X$ .

**Solution:**

$$\mathbb{E}[e^X] = e^{2 + \frac{1}{2}5} \approx 90.017.$$

Let us denote the median by  $m$ . Then,

$$\frac{1}{2} = \mathbb{P}[e^X \leq m] = \mathbb{P}[X \leq \ln(m)].$$

So, since the mean of the normal variable  $X$  is equal to 2,  $m = e^2 = 7.3891$ .

**Problem 4.2.** (2 points) The product of log-normal random variables is normal. *True or false?*

**Solution: FALSE**

The product of lognormals is itself lognormally distributed.

**Problem 4.3.** (2 points) The mean of a lognormal stock price is at most as large as its median. *True or false?*

**Solution: FALSE**

It's the other way around.

**Problem 4.4.** Let  $S(t)$  denote the time- $t$  stock price for  $t \geq 0$ . Let us use the Black-Scholes framework for the stock price. Then, the random variable

$$\ln \left( \frac{S(t)}{S(0)} \right)$$

has the log-normal distribution for every  $t$ . *True or false?*

**Solution: FALSE**

The realized returns have the normal distribution.

**Problem 4.5.** (5 points)

Assume the Black-Scholes framework for stock prices, i.e., assume the lognormal distribution of the stock prices. Let the mean rate of appreciation on a stock be 0.05 and let its volatility be equal to 0.25.

The continuously compounded risk-free interest rate is 0.04.

What is the probability that the stock will have a positive return over the period of two years?

- (a) 0.5438
- (b) 0.7704
- (c) 0.8554
- (d) 1
- (e) None of the above.

**Solution: (a)**

Let us denote the return over the period of two years by  $R(0, 2)$ . Then, in our usual parametrization and notation,

$$\mathbb{P}[R(0, 2) > 0] = \mathbb{P} \left[ \left( \alpha - \delta - \frac{\sigma^2}{2} \right) 2 + \sigma \sqrt{2} Z > 0 \right] = \mathbb{P} \left[ Z < \frac{\left( \alpha - \delta - \frac{\sigma^2}{2} \right) \sqrt{2}}{\sigma} \right]$$

where  $Z \sim N(0, 1)$ . The answer is

$$N\left(\frac{\left(0.05 - \frac{0.25^2}{2}\right)\sqrt{2}}{0.25}\right) = N(0.11) = 0.5438.$$