Applying the Models

Cost of Carry Model

Project: Calculate the futures price for a coffee contract maturing in six months using the current spot price, the risk-free interest rate, and the estimated storage costs.

Steps:

1. **Gather Data**:
   - **Spot Price**: Find the current spot price of coffee. You can obtain this from financial news websites like Bloomberg, Reuters, or commodity-specific sites like the International Coffee Organization (ICO).
   - **Risk-Free Rate**: Use the current yield on a six-month US Treasury bill as a proxy for the risk-free rate. This data can be found on financial websites like the US Department of the Treasury or FRED (Federal Reserve Economic Data).
   - **Storage Costs**: Estimate storage costs as a percentage of the spot price. This information might be available in commodity market reports or industry publications.
2. **Calculate Futures Price**:
   - Use the cost of carry formula:

   $$F_t = S_t e^{(r+d)T}$$

   - Where:
     - F_t: Futures price
     - S_t: Spot price
     - r: Risk-free rate
     - d: Storage cost
     - T: Time to maturity (0.5 years for six months)
3. **Python Implementation**:

```python
Copy code
import numpy as np

# Given values
S_t = 1.20   # Spot price in dollars
r = 0.02   # Risk-free rate (2%)
d = 0.01   # Storage cost (1%)
T = 0.5   # Time to maturity in years

# Calculating futures price
F_t = S_t * np.exp((r + d) * T)
print(f"The fair price of the coffee futures contract is ${F_t:.3f} per pound.")
```

Black-Scholes Model

Project: Price a call option on a coffee futures contract using the current spot price, strike price, risk-free rate, time to maturity, and volatility.

Steps:

1. **Gather Data**:
   o **Spot Price**: Use the same spot price data as for the futures contract.
   o **Strike Price**: Choose a strike price based on market conditions and option contracts available on exchanges like the ICE (Intercontinental Exchange).
   o **Risk-Free Rate**: Use the same risk-free rate as for the futures contract.
   o **Time to Maturity**: Specify the time to maturity (e.g., six months).
   o **Volatility**: Calculate or find the historical volatility of coffee prices. This data can be derived from historical price data available on financial websites or through databases like Yahoo Finance.
2. **Calculate Option Price**:
   o Use the Black-Scholes formula:

   $$C = S_0 N(d_1) - X e^{-rT} N(d_2)$$

   $$d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}$$

   $$d_2 = d_1 - \sigma\sqrt{T}$$

   o Where:
      ▪ C: Call option price
      ▪ S_0: Spot price
      ▪ X: Strike price
      ▪ r: Risk-free rate
      ▪ T: Time to maturity
      ▪ σ: Volatility
3. **Python Implementation**:

```python
python
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from scipy.stats import norm
import numpy as np

# Given values
S_0 = 1.20   # Spot price in dollars
X = 1.25   # Strike price in dollars
r = 0.02   # Risk-free rate (2%)
T = 0.5   # Time to maturity in years
sigma = 0.25   # Volatility (25%)

# Calculating d1 and d2
d1 = (np.log(S_0 / X) + (r + 0.5 * sigma ** 2) * T) / (sigma *
np.sqrt(T))
```

```
d2 = d1 - sigma * np.sqrt(T)

# Calculating call option price using Black-Scholes formula
C = S_0 * norm.cdf(d1) - X * np.exp(-r * T) * norm.cdf(d2)
print(f"The price of the call option is ${C:.3f}.")
```

Monte Carlo Simulation

Project: Run simulations to forecast the price of coffee futures under different market conditions. Evaluate the impact of varying supply, demand, and weather scenarios.

Steps:

1. **Gather Data**:
   - o **Initial Price**: Use the same spot price data.
   - o **Risk-Free Rate**: Use the same risk-free rate.
   - o **Volatility**: Use the same volatility data.
   - o **Simulated Period**: Define the time period for the simulation (e.g., six months).
2. **Run Simulations**:
   - o Use Monte Carlo simulations to generate numerous possible future price paths based on the inputs.
   - o Model the stochastic process of coffee prices using Geometric Brownian Motion (GBM).
3. **Python Implementation**:

```python
python
Copy code
import numpy as np

# Simulation parameters
S_0 = 1.20  # Spot price in dollars
r = 0.02  # Risk-free rate (2%)
sigma = 0.25  # Volatility (25%)
T = 0.5  # Time to maturity in years
num_simulations = 10000  # Number of simulations
num_steps = 252  # Number of steps (daily)

# Time increment
dt = T / num_steps

# Simulating price paths
np.random.seed(42)  # For reproducibility
price_paths = np.zeros((num_steps, num_simulations))
price_paths[0] = S_0

for t in range(1, num_steps):
    z = np.random.standard_normal(num_simulations)
    price_paths[t] = price_paths[t-1] * np.exp((r - 0.5 * sigma ** 2) *
dt + sigma * np.sqrt(dt) * z)

# Calculating the average simulated price at maturity
average_simulated_price = np.mean(price_paths[-1])
```

```
print(f"The average simulated price of the coffee futures contract at
maturity is ${average_simulated_price:.3f}.")
```

Data Sources and Tools

1. **Data Sources**:
   - **Spot Prices**: Bloomberg, Reuters, International Coffee Organization (ICO)
   - **Risk-Free Rates**: US Department of the Treasury, FRED (Federal Reserve Economic Data)
   - **Storage Costs**: Commodity market reports, industry publications
   - **Volatility Data**: Yahoo Finance, historical price databases
2. **Tools**:
   - **Python**: Use Python for data analysis and simulations. Libraries like NumPy, SciPy, and pandas are essential for financial modeling.
   - **Spreadsheet**: Use Excel for initial data gathering and simple calculations.

By following these steps and utilizing the provided data and tools, you will be able to apply quantitative models to price coffee futures contracts, structure options, and run simulations effectively. This hands-on approach will help you develop practical skills in quantitative analysis and financial modeling.