EUM Short Assignment 2: Stock Index Futures

In this short assignment, you will work with the simplest type of computer program, one that uses procedural programming techniques. Procedural programs are those written as lists of instructions divided into sections or units of code called the main block, plus subroutines and functions (Lesson 3). Procedural programming works well for small projects because it is very intuitive. Moreover, machine code in VBA is procedural, so compiling procedural code is very efficient.

The most widely traded equity index futures contract in the U.S. is the S&P 500. The futures contracts on the S&P 500 index are traded at the Chicago Mercantile Exchange (CME). The value of the contract is $250 times the futures price. The CME's "e-Mini" contract is a smaller, electronically-traded version of the original pit-traded contract and has a value of $50 times the futures price. So, if the futures contract was valued at 1000, it would have a notional value of $250,000 and the "e-Mini" a notional value of $50,000. The CME also trades options on these futures contracts. The Chicago Board Options Exchange (CBOE) trades options on the cash S&P 500 index. The S&P 500 Index consists of 500 stocks, each selected for their market size, liquidity, and industry group. Also, the S&P 500 is a market value weighted index where the market value of an individual stock is the stock price times the number of shares outstanding. Each stock's weight in the Index then is proportionate to its market value. The weights for the individual stocks change as their respective prices rise and fall relative to other stocks in the index. Alternatively, an index could be price weighted, where the index weights are proportional to the stock prices. The Dow Jones Industrial Average is an example of a price weighted index.

For this assignment I want you to build a simple program that will calculate the fair value of a futures contract on a market value weighted index.

Formula1 for the calculation of the fair value of a futures contract on a market value weighted index (*using the cost-of-carry model, see notes on "Cash and Carry Arbitrage" at the end of this document*):

$$F_{0,t} = S_0\left(1 + R\frac{T}{360}\right) - \sum_{i=1}^{n} D_i\left(1 + R\frac{\tau_i}{360}\right)$$

where,

$\sum$ $\quad$ $is\ the\ summarion\ operator, see\ http://en.wikipedia.org/wiki/Summation$

for example,

$$\sum_{i=1}^{n} D_i\left(1 + R\frac{\tau_i}{360}\right) = \left[D_1 \times \left(1 + R\frac{\tau_1}{360}\right)\right] + \left[D_2 \times \left(1 + R\frac{\tau_2}{360}\right)\right] \ldots. + \left[D_n \times \left(1 + R\frac{\tau_n}{360}\right)\right]$$

$F_{0,t} = Index\ futures\ price\ at\ time\ 0\ and\ expire\ t\ days\ in\ the\ future$

$S_0 = Value\ of\ the\ market\ value\ weighted\ cash\ index\ at\ time\ 0.$

$See\ Formula\ 2\ for\ the\ calculation\ of\ the\ \ cash\ value\ of\ a\ market\ value\ weighted\ index.$

$R = Interest\ rate$

$T = Number\ of\ days\ till\ futures\ expiration.$

$D_i = Amount\ of\ the\ i^{th}\ dividend.$

$\tau_i = Number\ of\ days\ the\ i^{th}\ dividend\ will\ be\ invested\ from\ receipt\ until\ futures\ expiration.$

Formula2 for the calculation of the cash value of a market value weighted index:

$$S\&P500 = \frac{\sum_{i=1}^{500} N_i P_i}{O.V.} \times 10$$

where,

$$\sum_{i=1}^{500} N_i P_i = (N_1 \times P_1) + (N_2 \times P_2) \dots . + (N_{500} \times P_{500})$$

$$O.V. = The\ Original\ Valuation$$

$$N_i = \text{Number of shares outstanding for the } i^{th} \text{ firm}$$

$$P_i = \text{Price per share of the } i^{th} \text{ firm}$$

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Step 1:

For this exercise you are going to create a new Module, and name the module "IndexFutures."

Step 2:

When the module opens up, you will be presented only with a window in which to write code. Write the "Sub Index_Future()" procedure to call the necessary functions to print the results in cell A1 for fair value of the index, and cell A2 for the cash value of the index .

Remember to include some sample values for the following variables in cells A3 to A13:

A3 → m_PriceA (as Double) = 100 'price of stock A
A4 → m_PriceB (as Double) = 75 'price of stock B
A5 → Index_original_value (As Double) = 2000
A6 → m_DaysTillExp (As Double) = 90
A7 → m_Rate (As Double) = 0.10
A8 → m_SharesA (As Integer) = 1000
A9 → m_SharesB (As Integer) = 2000
A10 → m_DivA (As Double) = 2.00 ' 2.00 dividend 40 days from now on A
A11 → m_DivB (As Double) = 1.00 ' 1.00 dividend 50 days from now on B

A12 → m_DaysDivAInvested (As Integer) = 50 ‘(90 - 40) = 50 days to invest dividend

A13 → m_DaysDivBInvested (As Integer) = 40 ‘(90 - 50) = 40 days to invest dividend

These values are necessary for the calculation of the fair value of a futures contract on a market value weighted index. **Notice that you have to use the correct value type for the variables.**

Step 3:

Write a function to calculate the fair value of the index. To do this, you will need to declare and define some input variables and use some mathematical operators according to the inputs and formulas above. **For simplicity, you will assume that there are two stocks in this index, known as stock A and stock B, and that it is a market value weighted index like the S&P 500.**

Step 4:

Once your code is finished, run the program by adding a button (Form Control)[1] and assigning the Index_Future macro to it in the worksheet.

[1] http://office.microsoft.com/en-001/excel-help/add-a-button-and-assign-a-macro-to-it-in-a-worksheet-HP010236676.aspx

Extra Credit:

All aspects of this section are optional. This is not part of your short assignment 2, is not required in any way and doing this section cannot have any negative impact on your grade. Doing this extra credit could help boost your overall grade of short assignment 2. In short, this could be a way of making up for lower than expected short assignment 2.

Futures contracts on the Dow Jones Industrial Average (DJIA) trade at the Chicago Board of Trade. To calculate the value of the DJIA, a price weighted index, the equation is:

$$DJIA = \frac{\sum_{i=1}^{30} P_i}{Divisor}$$

For the extra credit you will replicate Steps 1 to 4 and calculate the fair value of a two stock, price weighted index according to the price weighted index. Assume that the two stocks, A and B, are priced at 100 and 75 and pay dividends in the amounts and times shown in Step 2.

<u>Notes on "Cash and Carry Arbitrage"</u>

Although we are finished programming for the chapter, let's take a little more in depth look at the fair value of a futures contract on a stock index.

No-arbitrage conditions prevent the value of the index futures contract from moving too far away from the fair value. Cash-and-carry strategies prevent the futures price from getting too high relative to the cash stocks and reverse cash-and-carry arbitrage strategies prevent it from getting too low. Identifying opportunities for cash-and-carry arbitrage, however, necessitates the technological infrastructure to monitor the 500 stocks in real time and execute trades simultaneously. For this reason, these types of trading strategies are often referred to as "program trading," since they are computer generated.

In the following two examples illustrating index arbitrage, we assume that the prices of the underlying stocks A and B do not change over the 90 days, although the profit or loss does not in either case depend on the stock prices at expiration. Rather, the profit arises from a discrepancy between the futures price and its fair value on day 0.
The futures price must be equal to the cash index price plus the charges to carry the cash index forward to expiration. The carrying charge is the interest lost by being long the underlying stocks. If the prices do not fall in line with the cost of carry, a trader attempt a cash-and-carry or reverse- cash-and-carry arbitrage.

Numerical Example: Cash and Carry Arbitrage

A cash-and-carry arbitrage strategy involves selling the buying stock and selling the futures contract in a similar but opposite fashion. Here we replicate the index by weighting our portfolio with 3 parts stock B, $750, and 2 parts stock A, $500.

Time	Cash Market	Futures Market
0 days	Borrow $1250 for 90 days at 10%. Interest owed will be $ 31.25 Buy 5 shares of stock A at $100. Buy 10 shares of stock B at $75.	Sell 1 futures contract at 1285.00.
40 days	Receive $2.00 dividend on each share of stock A totaling $10. Invest proceeds for 50 days at 10%.	
50 days	Receive $1.00 dividend on each share of stock B totaling $10. Invest proceeds for 40 days at 10%.	
90 days	Sell 5 shares of stock A at $100. Sell 10 shares of stock B at $75. Receive total proceeds from invested dividends of $10.14 and $10.11. Total proceeds are $1270.25. Repay debt plus interest of $1281.25.	Buy 1 futures contract at fair value at expiration of 1250, which is the spot index value.
P and L	Loss: $11.00	Profit: $35.00
Total Profit of $35.00 – $11.00 = $24.00		

Numerical Example: Reverse Cash and Carry Arbitrage

A reverse cash-and-carry arbitrage opportunity involves selling the underlying stock and buying the futures contract in a similar but opposite fashion.

Time	Cash Market	Futures Market
0 days	Sell 5 shares of stock A at $100. Sell 10 shares of stock B at $75. Invest proceeds of $1250 for 90 days at 10%. Interest earned will be $31.25.	Buy 1 futures contract at 1255.00.
40 days	Borrow $10.00 for 50 days at 10%. Pay dividend on stock A. Interest owed will be $0.14.	
50 days	Borrow $10.00 for 40 days at 10%. Pay dividend on stock B. Interest owed will be $0.11.	
90 days	Buy 5 shares of stock A back at $100. Buy 10 shares of stock B back at $75. Repay debt plus interest of $20.25. Receive interest of $31.25.	Sell 1 futures contract at fair value at expiration of 1250, which is the spot index value.
P and L	Profit: $11.00	Loss: $5.00.
Total Profit of $11.00 – $5.00 = $6.00		