Finance Project

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Information is cheap, meaning is expensive.

— George Dyson

1 Introduction

In this project you will learn how to do the following things in MATLAB:

1. Read and write a simple formatted text file.
2. Use a *for* loop.
3. Plot a two-color bar chart.
4. Plot a line chart.
5. Practice more MATLAB built-in functions.

You will learn those MATLAB programming techniques in the context of a simple finance project: To compute daily, average daily, cumulative daily, and annualized daily rates of return; and to compute average daily and annualized daily volatility of return for a given stock.

These concepts may be new to some of you, and the first thing I want to do in this note is to explain the meaning of the four rates of return I mentioned above: **daily, average daily, cumulative daily, and annualized**. After that I will explain the two concepts of volatility: **average daily and annualized daily**.

1.1 Daily Rate of Return

On December 19, 2011, the closing price of Apple, Inc. stock was 382.21, and the next day, on December 20, 2011, the closing price of Apple stock was 395.95. If you bought a number of shares of Apple at the closing price on December 19, then by the close of trading on December 20 your rate of return was

$$\begin{aligned} \text{Return on Dec 20} &= \frac{\text{Closing price on Dec 20}}{\text{Closing price on Dec 19}} - 1 \\ &= \frac{395.95}{382.21} - 1 \\ &= 3.595\% \end{aligned} \tag{1}$$

1.2 Cumulative Rate of Return

On December 21 the closing price of Apple stock was 396.44 and on December 22 it was 398.55. We can calculate the daily rates of return in the same way as before

$$\begin{aligned} \text{Return on Dec 21} &= 0.124\% \\ \text{Return on Dec 22} &= 0.532\% \end{aligned} \tag{2}$$

Now comes the fun part: What is the cumulative return on Apple stock from December 19 through December 22? In other words, if you bought the stock at the closing price on December 19, and sold it at the closing price on December 22, what was your total return?

If you have never done such analysis before, you may jump to the conclusion that the answer comes from adding the daily returns

$$\begin{aligned} &\text{Cumulative Apple return from Dec 19 through Dec 22} = \\ &3.595\% + 0.124\% + 0.532\% = \\ &4.251\% \end{aligned} \tag{3}$$

But this would be **incorrect**. To dramatize the error, imagine that you buy a stock that goes up 50% the day after you bought it, and then declines 50% the day after that. The cumulative rate of return for the two days is not zero. For example, if you bought the stock for \$100, then the next day it goes up to \$150, and the day after that falls to \$75, so the cumulative two-day return is -25%. The correct calculation of the cumulative two-day return is

$$\text{Cumulative two-day return} = (1 + 0.50) \times \Big[1 + (-0.50)\Big] - 1 = -25\% \tag{4}$$

Going back to Apple stock, the three-day cumulative return from December 19 to December 22 is

$$\begin{aligned} &\text{Cumulative Apple return from Dec 19 through Dec 22} = \\ &(1 + 0.03595) \times (1 + 0.00124) \times (1 + 0.00532) - 1 = \\ &0.04275 = \\ &4.275\% \end{aligned} \tag{5}$$

First, note that I use daily returns in decimal form. For example, 1% is 0.01, and -0.54% is -0.0054.

Second, it is important to keep in mind that daily returns are not additive. If you get data on daily rates of return R_1, R_2, ..., R_N, and need to calculate cumulative return, the calculation has to be done as

$$\begin{aligned} &\text{Cumulative return from day 1 through day } N \quad = \\ &(1+R_1)\times(1+R_2)\times\cdots(1+R_N)-1 \end{aligned} \tag{6}$$

1.3 Average Daily and Annualized Rate of Return

If you have a sequence of daily rates of return, you can calculate the average daily rate of return from a formula that follows from Equation (6)

$$\begin{aligned} &\text{Average daily return from day 1 through day } N \quad = \\ &\left[(1+R_1)\times(1+R_2)\times\cdots(1+R_N)\right]^{\frac{1}{N}}-1 \end{aligned} \tag{7}$$

Then, after you calculate the average daily rate of return, you can annualize it according to

$$\begin{aligned} &\text{Annualized daily return from day 1 through day } N \quad = \\ &(1+\text{Average daily return from day 1 through day } N)^{252}-1 \end{aligned} \tag{8}$$

The number 252 that appears in Equation (8) is the average number of days in a year that U.S. stock markets are open for business.

1.4 Average Daily and Annualized Volatility

Volatility of rate of return is a measure of risk. In general, volatility is not the only possible measure of risk, but it is the only measure of risk that we will discuss in this project.

Average daily volatility is the standard deviation of the daily rate of return.

Annualized daily volatility is the average daily volatility times $\sqrt{252}$. Recall that 252 is the average number of trading days in a year. The reason that we multiply average daily volatility by $\sqrt{252}$ rather than by 252, is that volatility is the square root of variance. Annualized variance is average daily variance times 252. Annualized volatility, or square root of variance, is average daily volatility times the square root of 252.

2 In-Class Project

2.1 Simpler project

Let's start with a simpler project first:

The data file `returns.dat` contains an unknown number of consecutive daily returns for some stock. Each line in the data file has two numbers: Day number and daily rate of return in percent, for example, day 15 has daily return of −0.822%

```
15  -0.822
```

The percent sign does not appear in the data file, and there is no header.

Write a MATLAB program to do the following:

1. Read the data file and calculate cumulative daily rates of return for day 2, day 3, day 4, and so on, until the last day in the data file.

2. Plot a bar chart of daily rates return in percent, using two different colors for positive returns and negative returns (for example, green bars for positive and red bars for negative, or as shown in figure).

3. Plot a line chart without markers of cumulative daily rate of return in percent.

4. Calculate average daily and annualized daily rate of return.

5. Calculate average daily and annualized daily volatility.

6. Write an output text file named `cumulative_returns.dat` with three numbers in each line: Day number, daily return in percent, and cumulative return in percent (do not include a percent sign), for example

```
15   -0.822   2.999
```

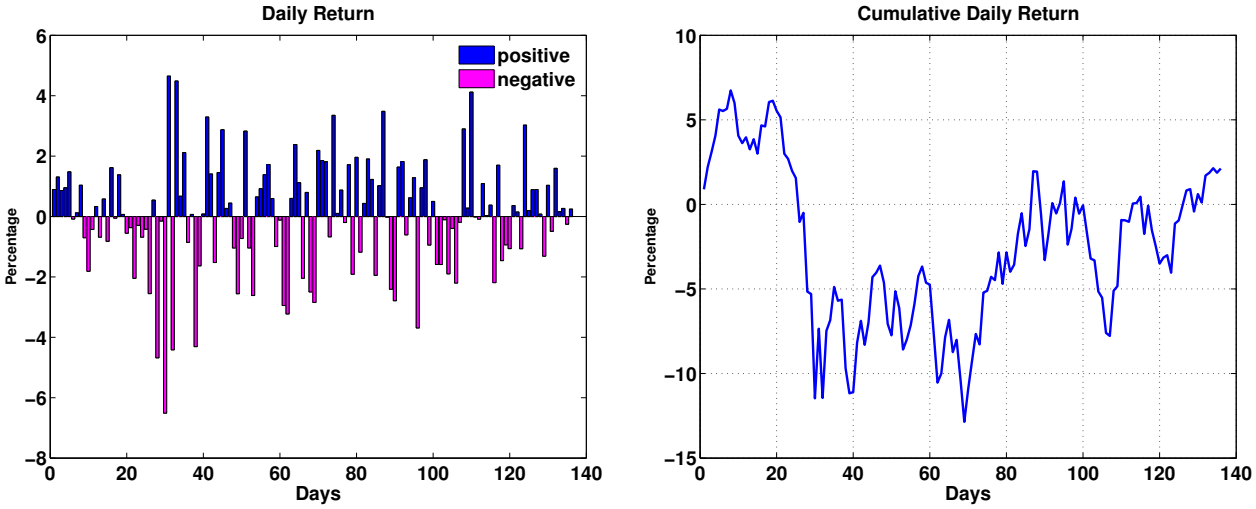

Figure 1. Daily return in bar chart and cumulative return in line chart

2.2 More complicated project

Often times, we don't have direct access to the daily return information. Common available information include: date, open, high, low, close, volume, adjusted close and/or dividend. In this part, we will start with these original information available online. The data file `Google_close.dat` contains Google stock closing price starting from Jan 3, 2011 till Jan 25, 2012. Write a MATLAB program to do the following:

1. Read the data file and calculate daily rate of return for day 2, day 3, day 4, and so on, until the last day in the data file.

2. calculate cumulative daily rates of return for day 2, day 3, day 4, and so on, until the last day in the data file.

3. Calculate average daily and annualized daily rate of return.

4. Plot a bar chart of daily rates return in percent, using green bars for positive returns and red bars for negative returns.

5. Plot a line chart without markers of cumulative daily rate of return in percent.

6. Calculate average daily and annualized daily volatility.

2.3 Advanced project

The data file `Google_price.dat` contains date and Google stock closing price information. There is a title with "Date" and "Price". The date are represented in the form of "YYYY-MM-DD".

Write a MATLAB program to repeat the above procedure listed in section 2.2. Find the date of the maximum daily return and minimum daily return over this time period and verify your answer with online chart at Google finance.

3 Lab Project

3.1 Stock performance comparison

The data files `returns_a.dat` and `returns_b.dat` contain an unknown number of consecutive daily returns for stocks A and B respectively. Each line in each data file has two numbers: Day number and daily return in percent.

The percent sign does not appear in the data files, and there are no headers.

Write a MATLAB program to do the following:

1. Read the two data files.

2. Calculate the difference between the daily rates of return for the two stocks, that is, daily rate of return for stock A minus daily rate of return for stock B. Call this difference between daily rates of return X.

3. Calculate and plot a line chart of the cumulative daily rate of return for A and B in a left-right split subplot, compare their cumulative rate of return at the end of the time period.

4. Plot a bar chart of the cumulative rate of return for X, using black bars for positive numbers and magenta bars for negative numbers.

5. Calculate annualized daily return and annualized daily volatility for X.

6. Calculate the ratio of the annualized daily return for X to the annualized daily volatility of X. This term is called the "Information Ratio". In finance term, it measures excess return of A over B per unit of extra risk.

7. Display the information ratio in the console.

Based on the results of your program, would you say that stock A was a better investment than stock B? Write a paragraph to explain your reasons. You may include a paragraph at the end of

your code as comments using block comments in MATLAB: highlight your text, choose "Text" in the top bar, and "comment".

The IR is often used as an indicator to evaluate a risk-adjusted performance. If IR is not positive, then stock A performs worse than stock B, and your analysis stops here. Things become interesting only when IR is positive, the magnitude of IR tells you about the relationship between relative performance of the two stocks. You want IR to be positive and large. That happens when either annualized daily return of X is positive and large, or the annualized daily volatility of X is small.

In terms of magnitude of IR, there is no strict theoretical cutoff point. According to some people, an IR = 1 is very good, it means that one stock did much better than the other even after adjustment for risk. An IR = 0.1 is not good, it means that after adjustment for risk, the better stock did not do well enough to justify the risk. According to some people, an IR = 0.25 is borderline.

Information ratio can also be used to describe a fund manager's performance. In that case the information ratio is calculated between the fund manager's portfolio performance and a pre-selected benchmark.

Table 1 shows the empirical distribution of information ratios of active managers. This table has been used as the industry standard.

Table 1. Empirical distribution of information ratios.

Information Ratio	Percentile	Manager Skill
1.0	90	Exceptional
0.5	75	Good
0.0	50	Above Average
-0.5	25	
-1.0	10	

3.2 Stock drawup and drawdown

Consider the following measure of risk in a given time of interval as an alternative to volatility. Denote time by an integer t, and assume that $0 \leq t \leq T$. Define the drawdown at time t as a cumulative rate of return from: (1) the maximum cumulative rate of return in the time interval $\left[0, t\right]$ to (2) the current time t. In other words, the drawdown is a measure of the peak-to-current time decline. **Develop a formula to compute and plot the drawdown for both stocks.**

The concept of drawup is defined symmetrically, as a measure of upside potential. Please complete the precise definition of drawup, and compute and plot the drawup for both stocks.

Note: Please note that some analysts define drawdown and drawup in terms of dollars instead of cumulative rate of return. Your assignment is to compute and plot them in terms of cumulative rate of return, as defined above.

4 Lab project submission

Please create folders for each problem. If there are source data required to run your program, you need to put the data under the same folder, so that as soon as I unzip your code, I can test your code. Please zip all the folders that contain programs you want to submit and name it `YourFirstname_P2.zip`, submit the zipped file to the WISE dropbox before 11:59PM on Sep 28.