BS3336

Aston University

BUSINESS SCHOOL

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Quantitative Methods for finance (QMF114)

Module convenor: **Dr Rami Chehab**

Duration: **Five-Week Coursework (due in December 13)**

Instructions:

The maximum length for this assessment is five single-sided A4 paper (Times New Roman, 1.5 spacing, 12 point). If you are required to make a decision while conducting a hypothesis test, use a 5% significance level (unless otherwise specified). Be sure to state your null and alternative hypotheses, rejection criterion and your decision. Do not answer questions with a simple "yes" or "no", but carefully justify your answers.

Furthermore, you should upload only one single PDF format file. This PDF file should consist of both your analysis and codes. In Particular, you should combine both PDF files into one PDF file. The first PDF file contains your written answer that includes your discussion and data analysis, while the other PDF file contains the code that you required to generate the figures and graphs in your first PDF file.

Note: Watch the Panopto video that shows you how to convert your analysis, discussion, and figures and codes into a single PDF file.

Part One: Estimating and Testing the Capital Asset Pricing Model (CAPM) (60 marks)

In this exercise, we use monthly data to estimate the 'betas' of stocks (equities) traded on the New York Stock Exchange. We study equations of the from:

$$r_{jt} = \alpha_j + \beta_j r_{mt} + u_{jt} \tag{1}$$

where r_{jt} represents the actual return to holding company j's stock in month t, r_{mt} is the return on the market portfolio in month t (i.e., the portfolio consisting of all stocks, held in the same proportions as the market as a whole) and u_{jt} represents other influences on returns of the stock j.

The strict form of the capital asset pricing model (CAPM) predicts that this equation fully 'explains' stock returns. Specifically, this means that u_{jt} depends only on random effects particular to company j, and is not predictable by macroeconomic variables. According to the CAPM, when markets operate efficiently in response to complete information, market equilibrium implies that r_{mt} contains all such information, relevant to individual stock returns. In this exercise you will be required to test empirically all your doubts and assumptions you had about the financial data given to you using econometric techniques learned in your lectures and tutorials.

The parameter β (the 'beta') is an indicator of the risk and return associated with the stock. When $\beta_j = 1$, the expected net return is the same as that of the market portfolio. When $\beta_j > 1$, the expected return exceeds that of the market portfolio, but there is correspondingly greater risk. When $\beta_j < 1$ there is lower return, but also less risk. Thus, market equilibrium ensures the existence of a risk-return trade-off. The CAPM model also predicts that $\alpha_j = 0$ i.e. it is not widely believed that one entity in the stock market can outperform the market.

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Important Descriptions

Using our lab sessions, you can import the excel file known by 'Data_For_Analysis.xlsx' into your jupyter notebook. This file contains series of monthly returns on the stocks of 21 American companies, as follows:

Industry	Company	Variable Name	Period
Oil	Mobil	MOBIL	Jan78-Dec87
	Texaco	TEXACO	
Computers	IBM	IBM	
	Digital Equipment Co.	DEC	
	Data General	DATGEN	
Electricity	Consolidated Edison	CONED	
	Public Service of New Hampshire	PSNH	
	General Public Utilities	GPU	
Forestry	Weyerhauser	WEYER	
	Boise	BOISE	
Electronics	Motorola	MOTOR	
	Tandy	TANDY	
Airlines	Pan American	PANAM	
	Delta	DELTA	
Banks	Continental Illinois	CONTIL	
	Citicorp	CITCRP	
Food	Gerber	GERBER	
	General Mills	GENMIL	
Chemicals	Dow	DOW	Jan 78-Dec 85
	Dupont	DUPONT	Jan 78-Dec 85
	Conoco	CONOCO	Jan 78-Dec 81

Table 1: Note: Conoco was taken over by Dupont in September 1981. All the data are in period Jan78-Dec87 unless specified

The data file also contains the following variables:

MARKET	a measure of the market return	Jan 76 - Dec 87
RKFREE	return on 30 day U.S. Treasury bills	Jan 76 - Dec 87
GOLD	% change in the gold price	Jan 76 - Dec 85
CPI	U.S. consumer price index	Dec 77 - Dec 87
POIL	price of domestic crude oil	Dec 77 - Dec 87
FRBIND	index of U.S. industrial production	Dec 77 - Dec 88

Choose some stocks to analyse. Look at as many cases as you wish, but you must write up your analysis for two stocks, from different industries. The measure of r_{mt} is MARKET.

It is recommended that you divide the sample into two 5-year periods, and choose one of the periods for your analysis. Over a more extended period, a company's beta might change significantly (it is advised that you test for this and report it in your analysis).

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The Exercise

The following question follows from your Python tutorials from your module. In particular, you should always refer to the codes you have learned there i.e. use similar arrangements to get to the analysis required.

1. (5 marks) Upload all the data available in 'Data_For_Analysis.xlsx' onto your Jupyter Notebook. Set the index of the newly uploaded dataframe to the Date column, using the command 'set_index'. Furthermore, select from this table only two stocks such that each stock is from different industry as well as the Market stock return ('MARKET' column). Then, clean the Data by removing the Not a number (Nan) data points from your selected series.

2. (5 marks) Plot your data set. Check how the returns behave in exciting periods, such as the market crash of October 1987. Produce a scatter plot of r_{jt} against r_{mt} and comment on the observations. Explain from an economics or finance knowledge that you acquired what has been going on in these "remarkable" period(s) you have observed. Furthermore, compare the stocks you have chosen to the stock market as well as the companies in the same industries as your chosen stocks.

3. (5 marks) Use ordinary least squares (OLS) to estimate α and β. Calculate the approximated 95% confidence intervals for the parameters, and test the null hypotheses, $\alpha = 0$, and also $\beta \leq 1$ against the alternative hypotheses $\alpha \neq 0$ & $\beta > 1$, respectively. Interpret the result of both tests. Comment on the representations of α and β and their uses throughout finance. Furthermore, comment on and justify the outcome of the test based on your selected stock from both statistical and financial prospective. Furthermore, compare your selected stocks to the relative industry and here you may compare them using any method you learned throughout the module you may also reference to any additional readings you have made in this regards relative to your stocks.

4. (5 marks) It is known that the standard deviation of the OLS residuals in CAPM measures the individual risk of the stock, based on your knowledge comment on the reason for this (i.e. why do you think that the standard deviation of the OLS regression represent the individual risk)[1]. Compute and report your standard deviations (for both stocks) and comment on it. Furthermore, after computing both values (standard deviation of the residuals of both your stocks) perform some analysis that you think is adequate to compare them from a financial as well as statistical framework.

5. (5 marks) Some economists attribute R^2 of the regression measures as the proportion of the risk attributable to the market (as opposed to individual factors). Why is that based on your knowledge of regression analysis (goodness of fit) and CAPM? Comment on the values you observe when computing the R^2 of both of your stock returns.

6. (10 marks) Use the Chow stability test to check whether the model is stable over the full period of the sample at hand. Comment on the findings and justify with reference to news and other published articles what had actually happen to your stock at this particular event (special occasion)? For example, is there a difference between different stocks when it comes to Chow test, if so, why is that based on your econometric and economics or finance knowledge?

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[1] Here you can reference any textbook or published papers that report this phenomenon.

7. (15 marks) In this exercise you are requested to test the strict CAPM against the alternative of the Arbitrage Pricing Model (APM) by testing the ability of macroeconomic variables to predict returns. To do so, we will require the following sequential steps to be applied to get your data sorted:

   (a) Compute the rate of inflation (RINF), the growth in industrial production (GIND), and changes in the real oil price (ROIL) which are essential the percentage monthly changes in CPI, FRBIND and POIL/CPI, respectively.

   (b) Add the computed variables to your initial Dataframe df.

   (c) Comment on the financial reasoning behind diving the $POIL$ by CPI. Why it is important to do so?

   (d) Select the following columns $['Stock1','Stock2','MARKET','RINF','GIND','ROIL']$ from your updated Dataframe df and call it $df1$.

   (e) You will find that in your new Dataframe there are elements that are not a number (NaN). Delete these elements using $df1 = df1.dropna()$.

   In this exercise, you will have to innovate in many perspectives. For example, perform a general fit of a model, comment on the statistical significance of the variable empirically, do you think the CAPM was better than the APM in modelling the returns of your chosen stocks? Here, you can do lots of issues and you need to be deep in your ideas. Please mention why are you doing the thing you are doing as you go through your Jupyter notebook comments.

   Also test the joint significance, using an F test and Wald Test. Also report the summary and comment on your analysis.

8. (10 marks) This question is a bit of a broad subject, and its sole purpose is to provide you with a more in-depth insight into the idea of "expectation." Recall the CAPM equation used in class is different than the one presented in this Course Work i.e. Equation (1). In particular, in class, we have developed the following simple linear regression model:

$$r_{jt} - r_{ft} = \gamma_{0j} + \gamma_{1j}\left(r_{mt} - r_{ft}\right) + \varepsilon_{jt} \tag{2}$$

   where obviously we used to denote γ_{0j} by α_j and γ_{1j} by β_j. Recall that r_{ft} denotes the risk-free rate at time t.

   It turns, using mathematical techniques, that β_j in Equation (1) is

$$\beta_j = \frac{E(r_{jt}) - r_f}{E(r_{mt}) - r_f} \tag{3}$$

   where r_f is expected return on the risk-free rate over time (as it will be clearer later in the text). Equation (3) describes the subjective expectations of market traders in equilibrium at date t, which are of course unobserved. However, we might expect that the average values of $E\left(r_{mt}\right)$ and $E\left(r_{jt}\right)$ over time might be approximated by the sample average realized returns over time, which we do observe[2].

   While r_f, the average risk-free rate, the risk-free rate (measured by $RKFREE$) is not constant (although varying much less than the equity returns). It is reasonable to expect that the time average of this variable, $RKFREE$, would measure the average risk-free rate. An informal check on the CAPM might in this case be provided by calculating the ratio on the right-hand side of equation (3) with sample means replacing theoretical values, and comparing this with the OLS estimate of β_j for the same time period. Do so and comment on your findings. Furthermore, estimate —using OLS— Equation (2) and comment on the estimated γ_{1j} for both of your stocks

[2]For more details on the topic, you may, but you are not obliged to, get more information on *subjective expectations of market* in this link or by downloading the paper from here.

and compare it with that available in equation (3). What do you think the difference between both variables γ_{1j} and β_j when it comes to the financial interpretation?

Part Two: Econometrics & Forecasting (40 marks)

This exercise is a follow-up question to the previous part. Although this exercise is more dedicated to forecasting questions, you may always refer to your previous arguments in exercise 1. In particular, your comments are still relevant in this context, and you may always refer to them when needed[3].

1. (10 marks) The estimation of parameters in a linear regression model such as the CAPM and APT has received significant attention in the statistics and econometrics literature. Much of the work reported is based on the assumption of normality. Do you think that after running the estimation of the CAPM model in the previous problem set of both your stocks, do you think that the residuals follow a normal distribution? Why should we be worried if they do not?

2. (15 marks) During lectures, we have covered lots of topics on forecasting and how to perform prediction. Here, you are requested to apply all the forecasting methods (Naive, moving average, autoregressive, etc) on your data and report their forecasting accuracy using loss functions (MSE, RMSE, etc.). Furthermore, you are requested to mention the pros and cons of each method and comment on whether you support one method over the other.

   Note: It could be that your views and the method of forecasting you prefer is different from the lecturer's general views discussed in the lectures and seminars.

3. (10 marks) In the lectures, we have applied lots of econometric techniques that you were not required to apply in this course work including testing the out-performance or under-performance of a stock relative to the industry (which you initially chosen). Why, from your point of view, would it have been better to apply these methods and why do you think they are appropriate in this course work?

4. (5 marks) Based on all the econometric testing and application that you learned based on this course work, summarize what you have learned from your selected stocks?

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[3]Please do not replicate the econometric tests and techniques you have done in your previous exercises, as you will not gain any additional marks for your replications. However, it is advised to state why you picked a test as opposed to other available tests based on your conclusions with references to your previous work.