SESSION 5A: DATA RELATIONSHIPS IN FINANCE

Session 5
Correlations, Covariances and Regressions

Macro and Micro Questions

- <u>Micro versus Macro</u>: In finance, we look for relationships between both macro variables (interest rates and inflation, for exam), as well as micro variables (a company's profit margins and its revenue growth).

- <u>Motives</u>: You can look at the relationship between variables both for understanding and for forecasting.

  - <u>For analysis</u>: We look at the relationship between two or more variables to get an understanding of why they move (or don't move) together, with the hope that this understanding will lead to better policy:

  - <u>For prediction</u>: We also look at relationships between two or more variables to make better forecasts of one of the variables for the future, in the hope of acting on those forecasts.

How risky is a stock?

- The Capital Asset Pricing Model (CAPM) is one of finance's most common used and misused models to estimate expected return on risky investments. In the CAPM,
  - The risk of an investment is the risk added to the market portfolio, which is a diversified portfolio of all risky, traded assets.
  - To measure that risk, you have to look at how the investment moves with the market portfolio, with investments that move more being more risky.
- The tool that is used to measure this co-movement is a regression, with past returns on the investment regressed against past returns on a market index.

1. A Scatter Plot & Best Fit Line: Disney versus S&P 500

Return on Disney = .0071 + 1.2517 Return on Market

$R^2 = 0.73386$
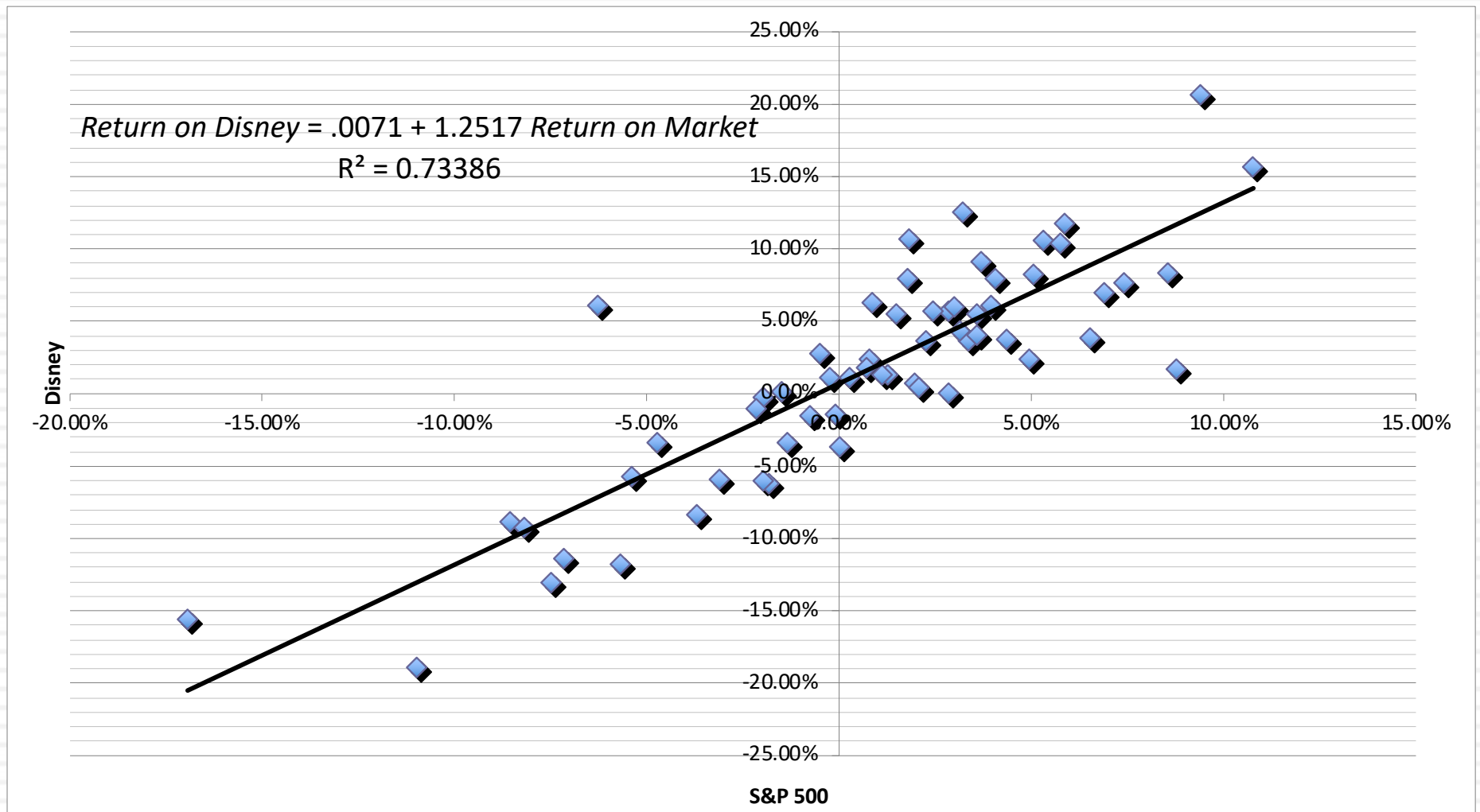
Disney

S&P 500

Correlation and Covariance

- The correlation coefficient between Disney and S&P 500 returns is captured (in a correlation matrix):

R	Disney	S&P 500
Disney	1	
R Std Err		
t		
S&P 500	0.85666	1
R Std Err	0.00459	
t	12.64646	

- The covariance is the non-standardized measure of this co-movement, and it is captured in the table below:

	Disney	S&P 500
Disney	0.00574	
S&P 500	0.00337	0.00269

Reading a Regression

A test of autocorrelation in residuals
<2 Positive
2-4 Negative

SS is the squared error explained (regression) and unexplained (residual). MS is SS dividend by the degrees of freedom.

A function of sample size & number of independent variables.

Measures whether independent variables are adding predictive value

Linear Regression						
Dependent variable	Return(Disney)					
Independent variables	Return(S&P 500)					
Return(Disney) = 0.00712 + 1.25173 * Return(S&P 500)						
Regression Statistics						
R		0.85666	R-Squared	0.73386		
			Adjusted R-Squared	0.72927		
Durbin-Watson (DW)		2.20472	Log likelihood	109.38276		

ANOVA						
	d.f.	SS	MS	F	p-value	
Regression	1	0.25276	0.25276	159.93306	0.	
Residual	58	0.09166	0.00158			
Total	59	0.34442				

|			95% Confidence interval				
	Coefficients	Std Err	LCL	UCL	t Stat	p-value	H0 (5%)
Intercept	0.00712	0.00519	-0.00326	0.0175	1.37264	0.17515	Accepted
Return(S&P 500)	1.25173	0.09898	1.0536	1.44986	12.64646	0.00000	Rejected

The lower (LCL) and upper (UCL) ends of the range are computed by subtracting or adding two standard errors to coefficient.

The t statistic and p value measure whether the specific independent variable adds predictive value in regression.

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2. A Time Series Example: Earnings to Price ratios and Interest Rates

Earnings to Price Ratio and Interest Rates

Aswath Damodaran
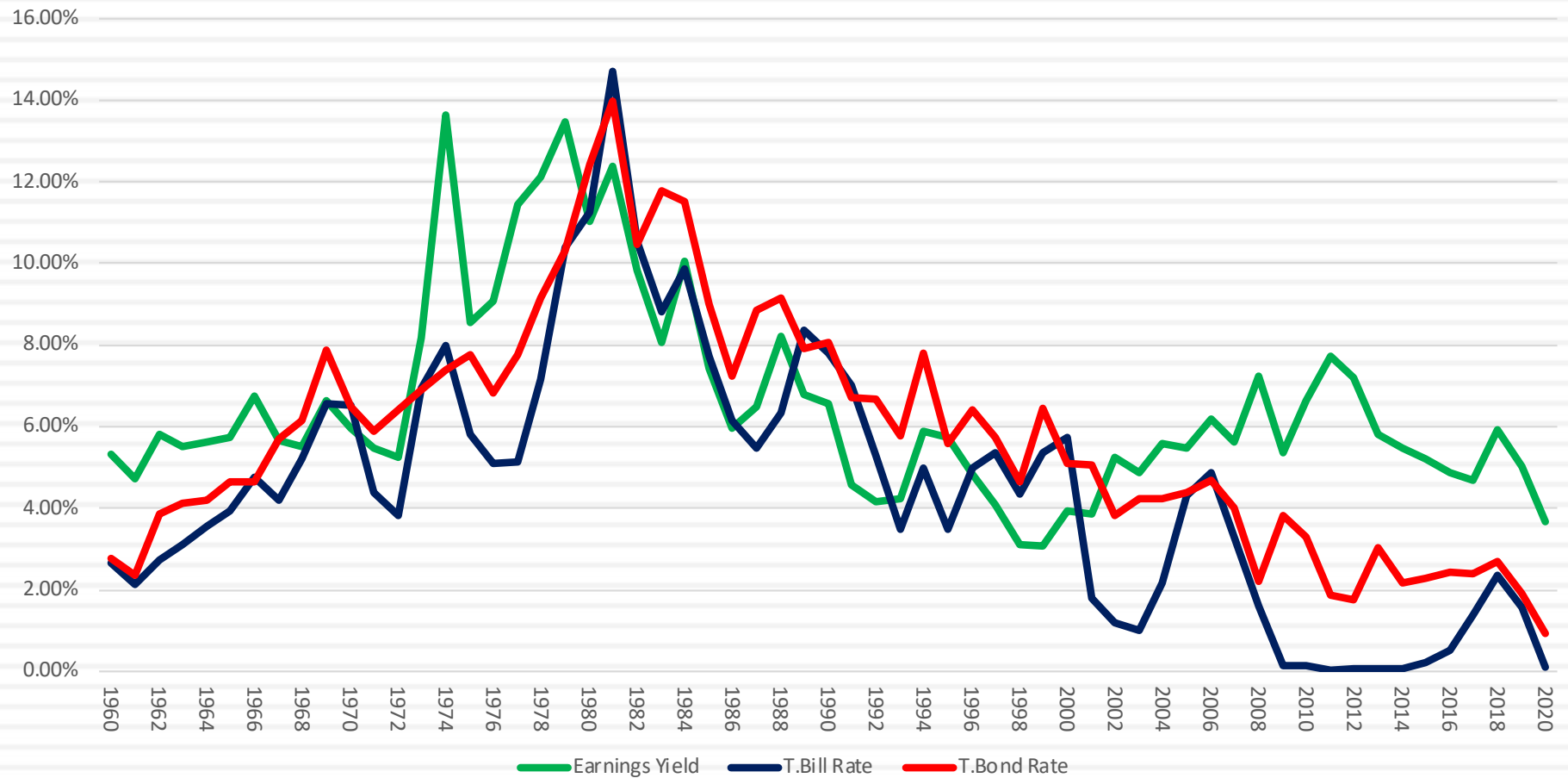
Covariances and Correlations

Covariances

	Earnings Yield	T.Bill Rate	T.Bond Rate
Earnings Yield	0.00059		
T.Bill Rate	0.00048	0.00101	
T.Bond Rate	0.00044	0.00086	0.00084

Correlations (Pearson)

R	Earnings Yield	T.Bill Rate	T.Bond Rate
Earnings Yield	1		
R Std Err			
t			
p-value (2-tailed)			
T.Bill Rate	**0.61862**	1	
R Std Err	0.01046		
t	6.04777		
p-value (2-tailed)	1.07728E-7		
T.Bond Rate	**0.63253**	**0.93175**	1
R Std Err	0.01017	0.00223	
t	6.27285	19.71042	
p-value (2-tailed)	4.53895E-8	0	

Correlations in bold are significant at the 5% level (2-tailed).
N of valid cases = 61.

R			
VAR vs. VAR	R	N	p-value
T.Bond Rate vs. T.Bill Rate	0.93175	61	0
T.Bond Rate vs. Earnings Yield	0.63253	61	4.53895E-8
T.Bill Rate vs. Earnings Yield	0.61862	61	1.07728E-7

A Scatter Plot of earnings yield on T.Bond rate, with a best-fit line..

Scatter Plot of Earnings Yield by T.Bond Rate

R^2 Linear = 0.400

$y=3.46+0.53*x$
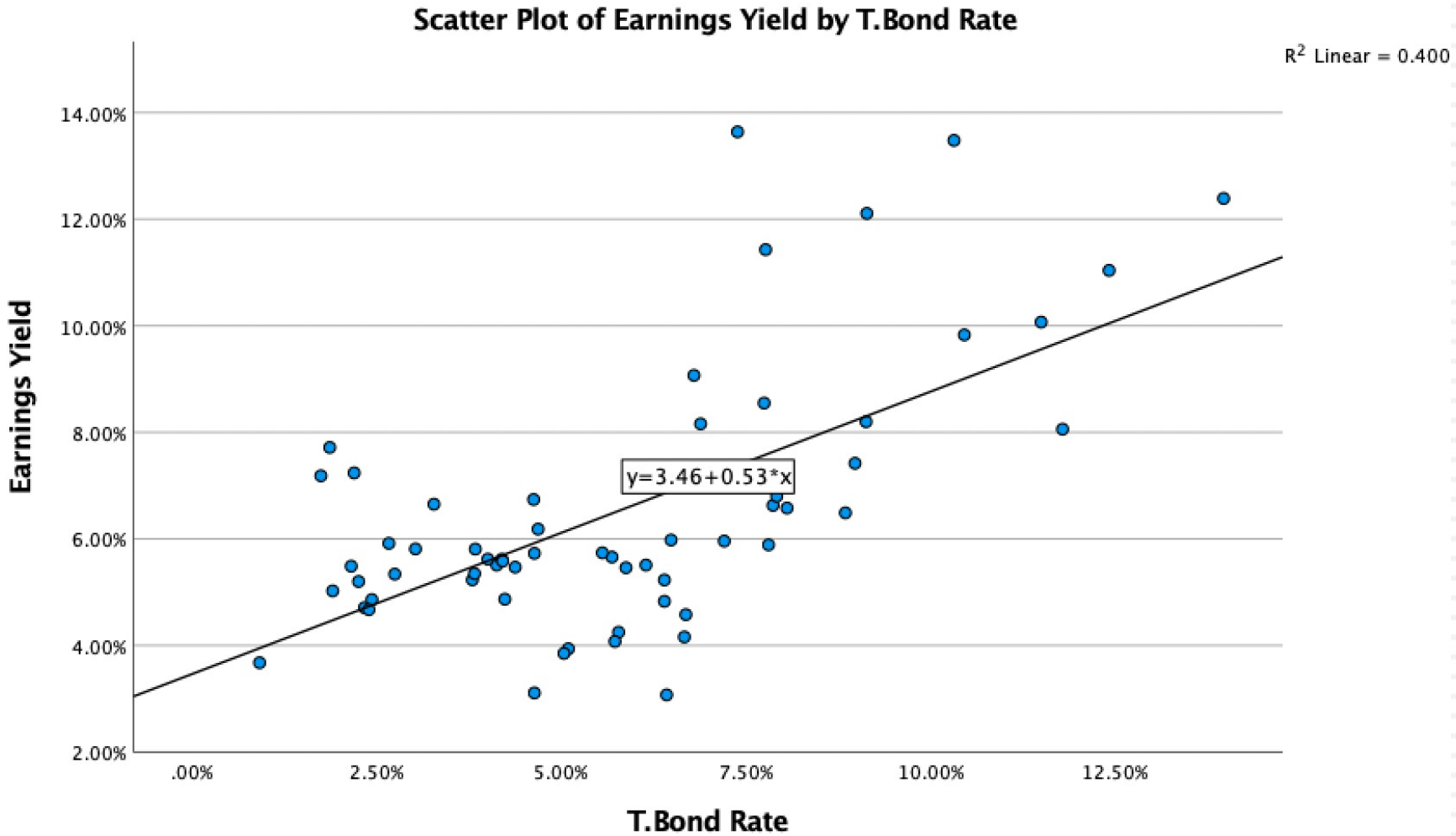
Regression and Prediction

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.633[a]	.400	.390	1.90780%

a. Predictors: (Constant), T.Bond Rate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	143.218	1	143.218	39.349	<.001[b]
	Residual	214.743	59	3.640		
	Total	357.961	60			

a. Dependent Variable: Earnings Yield
b. Predictors: (Constant), T.Bond Rate

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.457	.548		6.310	<.001
	T.Bond Rate	.530	.085	.633	6.273	<.001

a. Dependent Variable: Earnings Yield

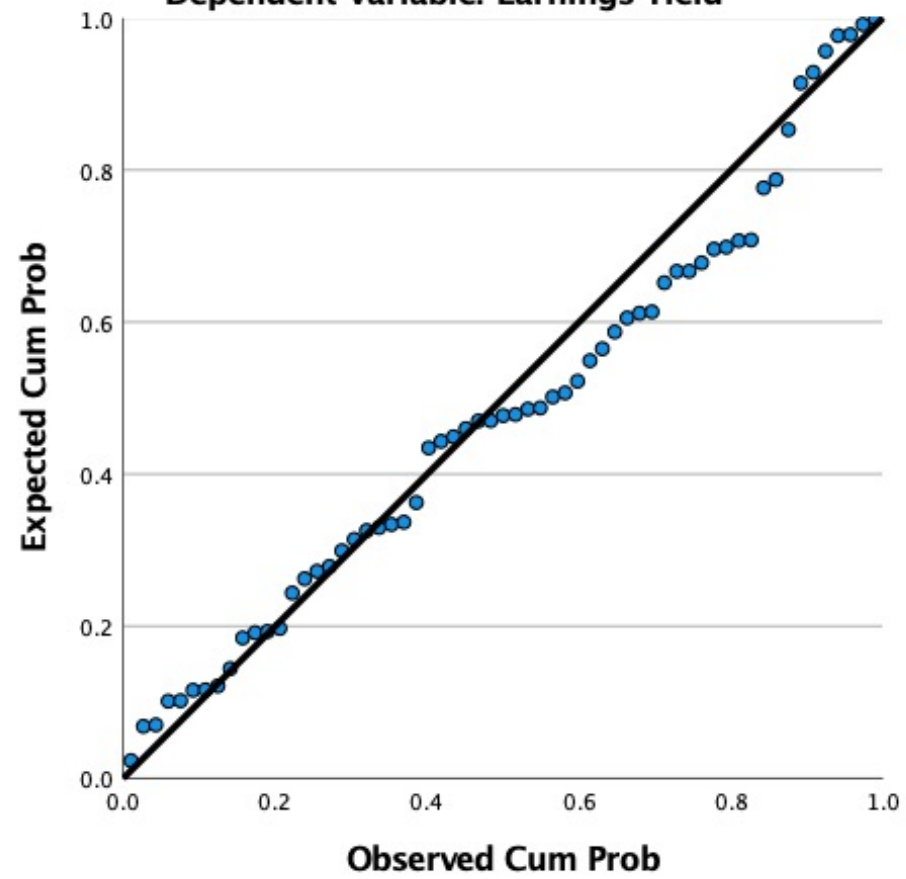If the T.Bond rate right now is 2%, the predicted Earnings yield is:

Predicted E/P = 3.457% + .530 (2%) = 4.517%

The actual E/P ratio on January 1, 2021 was 3.68%, making stocks over valued.

Regression Diagnostics

3. A Cross-sectional Example: European Banks in 2013

Name	Bloomberg symbol	PBV Ratio	Return on Equity	Standard Deviation
BAYERISCHE HYPO-UND VEREINSB	HVM GR Equity	0.80	-1.66%	49.06%
COMMERZBANK AG	CBK GR Equity	1.09	-6.72%	36.21%
DEUTSCHE BANK AG -REG	DBK GR Equity	1.23	1.32%	35.79%
BANCA INTESA SPA	BIN IM Equity	1.66	1.56%	34.14%
BNP PARIBAS	BNP FP Equity	1.72	12.46%	31.03%
BANCO SANTANDER CENTRAL HISP	SAN SM Equity	1.86	11.06%	28.36%
SANPAOLO IMI SPA	SPI IM Equity	1.96	8.55%	26.64%
BANCO BILBAO VIZCAYA ARGENTA	BBVA SM Equity	1.98	11.17%	18.62%
SOCIETE GENERALE	GLE FP Equity	2.04	9.71%	22.55%
ROYAL BANK OF SCOTLAND GROUP	RBS LN Equity	2.09	20.22%	18.35%
HBOS PLC	HBOS LN Equity	2.15	22.45%	21.95%
BARCLAYS PLC	BARC LN Equity	2.23	21.16%	20.73%
UNICREDITO ITALIANO SPA	UC IM Equity	2.30	14.86%	13.79%
KREDIETBANK SA LUXEMBOURGEOI	KBL LX Equity	2.46	17.74%	12.38%
ERSTE BANK DER OESTER SPARK	EBS AV Equity	2.53	10.28%	21.91%
STANDARD CHARTERED PLC	STAN LN Equity	2.59	20.18%	19.93%
HSBC HOLDINGS PLC	HSBA LN Equity	2.94	18.50%	19.66%
LLOYDS TSB GROUP PLC	LLOY LN Equity	3.33	32.84%	18.66%

Three-dimensional scatter plot

Simple 3-D Scatter of PBV by ROE by StdDev
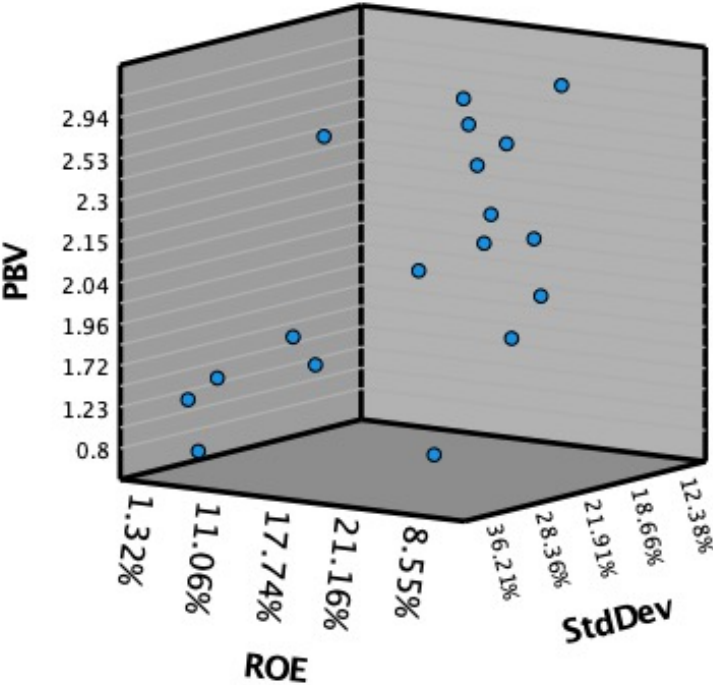
Correlation Matrix

- You can compute correlations across pairs of variables for as many variables as you want, with the caveat that the number of correlations you have to compute will increase at a much faster rate than the number of independent variables.

- The pair-wise correlations computed can be read the same way as simple correlations, ranging between + 1 and -1.

R	PBV Ratio	Return on Equity	Standard Deviation
PBV Ratio	1.0000		
R Std Err			
t			
Return on Equity	0.8682	1.0000	
R Std Err	0.0154		
t	6.9977		
Standard Deviation	-0.8283	-0.7644	1.0000
R Std Err	0.0196	0.0260	
t	-5.9126	-4.7424	

Multiple Regressions

Linear Regression						
Dependent variable	PBV Ratio					
Independent variables	Return on Equity, Standard Deviation					
Regression Statistics						
R		0.90494	**R-Squared**		**0.81892**	
MSE		0.08066	*Adjusted R-Squared*		0.79478	
PBV Ratio = 2.26677 + 3.62891 * Return on Equity - 2.67729 * Standard Deviation						
			ANOVA			
	d.f.	*SS*	*MS*	*F*	*p-value*	
Regression	2	5.47185	2.73592	33.91886	2.71627E-6	
Residual	15	1.20991	0.08066			
Total	17	6.68176				
			95% Confidence Interval			
	Coefficients	*Std Err*	*LCL*	*UCL*	*t Stat*	*p-value*	*H0 (5%)*
Intercept	2.26677	0.40802	1.39708	3.13645	5.55546	0.00006	*Rejected*
Return on Equity	3.62891	1.09369	1.29777	5.96005	3.31805	0.00468	*Rejected*
Standard Deviation	-2.67729	1.15203	-5.13278	-0.2218	-2.32398	0.03458	*Rejected*

Predictions and Residuals

	PBV Ratio	Predicted PBV	Residual
HVM GR Equity	0.79859	0.89324	-0.09465
CBK GR Equity	1.08757	1.05332	0.03425
DBK GR Equity	1.231	1.3566	-0.1256
BIN IM Equity	1.6605	1.40925	0.25125
BNP FP Equity	1.72301	1.88816	-0.16515
SAN SM Equity	1.85809	1.9088	-0.05071
SPI IM Equity	1.9612	1.86377	0.09743
BBVA SM Equity	1.97547	2.17367	-0.1982
GLE FP Equity	2.04314	2.01556	0.02758
RBS LN Equity	2.09153	2.50928	-0.41775
HBOS LN Equity	2.15222	2.4941	-0.34188
BARC LN Equity	2.23284	2.47984	-0.247
UC IM Equity	2.29741	2.43677	-0.13936
KBL LX Equity	2.45553	2.57913	-0.12361
EBS AV Equity	2.52774	2.05321	0.47453
STAN LN Equity	2.5889	2.46551	0.12339
HSBA LN Equity	2.94003	2.41157	0.52846
LLOY LN Equity	3.32586	2.95884	0.36703

Residual Chart for European Banks

Residuals vs Predicted Y
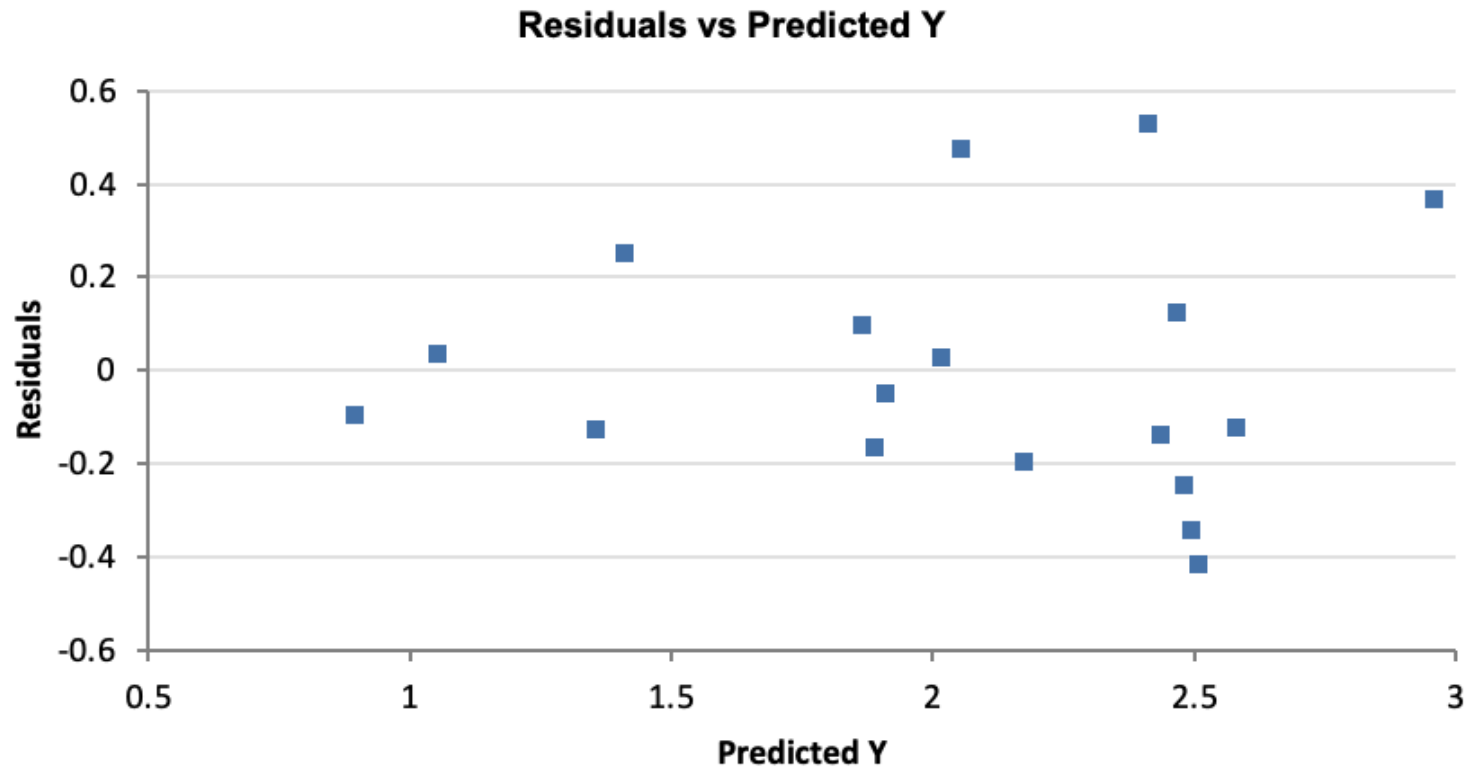
Breusch-Pagan-Godfrey (BPG) test				
Test Statistic	3.34529	*p-value*	0.18775	*H0 (5%)*	Cannot reject
F	1.71206	*p-value*	0.21394		
White test (All cross-terms)				
Test Statistic	4.45339	*p-value*	0.48614	*H0 (5%)*	Cannot reject
F	0.78899	*p-value*	0.57729		