4.3 SIM Regression: The Security Characteristic Line

ZZBU8701

Applying the SIM

SIM Regression

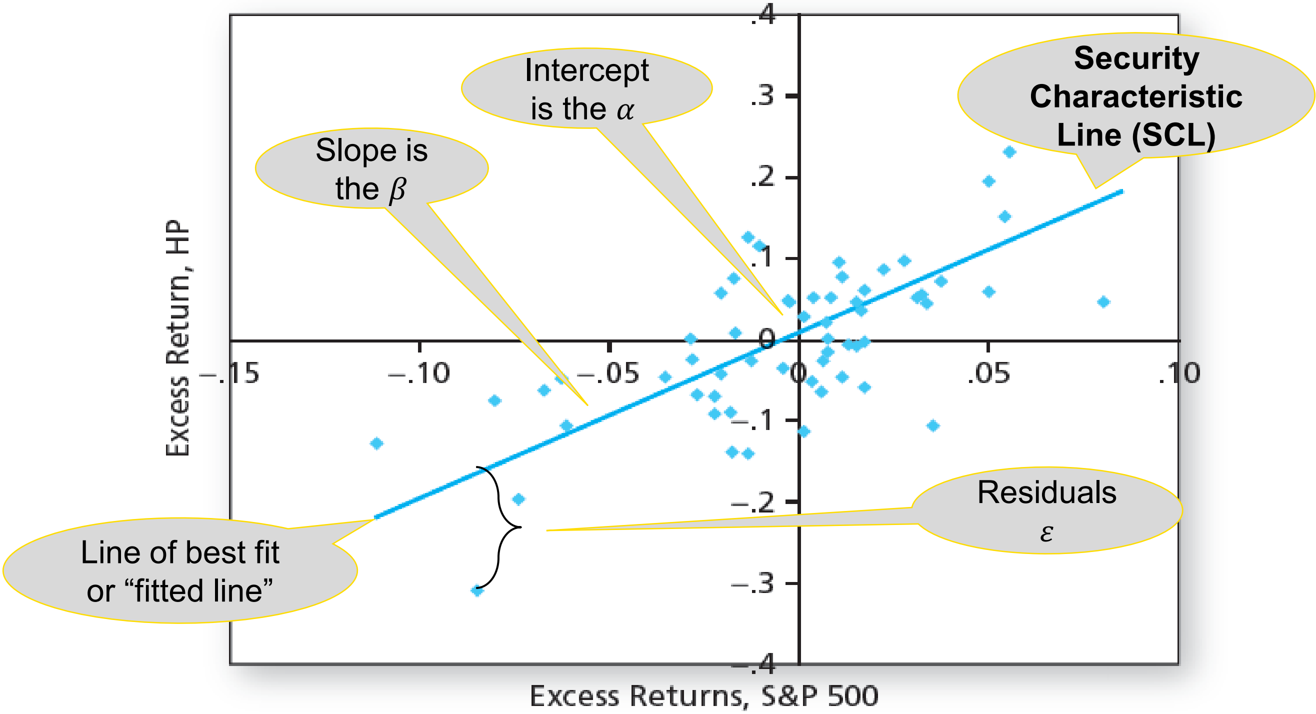
- Say we wanted to determine the relationship between the returns on a single stock and the market by way of regression. As a minimum we would want to know:
  - How the stock moved with the market – its β
  - The portion of the stock's return which is NOT explained by market movements – its α
  - The volatility of the stock's return including the proportional volatility coming from market movements vs firm-specific factors – it's total risk, systematic risk and unsystematic risk
  - The proportion of the stock's movement which is explained by market movements – it's R^2
  - We may even want to plot the relationship graphically
- In the simplest case - regressing a single stock against the market – we have only two variables:
  - The dependent variable – stock returns (or excess returns) which we plot on the **y-axis**
  - The independent variable – market returns (or excess returns) which we plot on the **x-axis**
  - **This graphical representation is called the Security Characteristic Line (SCL)**

Security Characteristic Line Example 1 - HP

- As an example, assume we are regressing HP's (Hewlett Packard) excess returns against the S&P500's excess returns (as a proxy for the market). We use the following equation:

$$R_{HP_t} = \alpha_{HP} + \beta_{HP} R_{S\&P500_t} + \varepsilon_{HP_t}$$

- If we had 5 years of monthly data, we would have 60 monthly observations. Each plot point on our graph represents a monthly observation (from BKM 8.3)



- The line of best fit (or fitted line) is the regression line which best describes the relationship between R_{HP_t} and $R_{S\&P500_t}$
  - The α is the intercept
  - The β is the slope
  - The residuals ε represent deviations from the fitted line

HP's SCL Regression Statistics Example 1

Regression Statistics	
Multiple R	.7238
R-square	.5239
Adjusted R-square	.5157
Standard error	.0767
Observations	60

		Coefficients	Standard Error	t-Stat	p-Value
Intercept	α	0.0086	.0099	0.8719	.3868
S&P 500	β	2.0348	.2547	7.9888	.0000

Correlation Coefficient

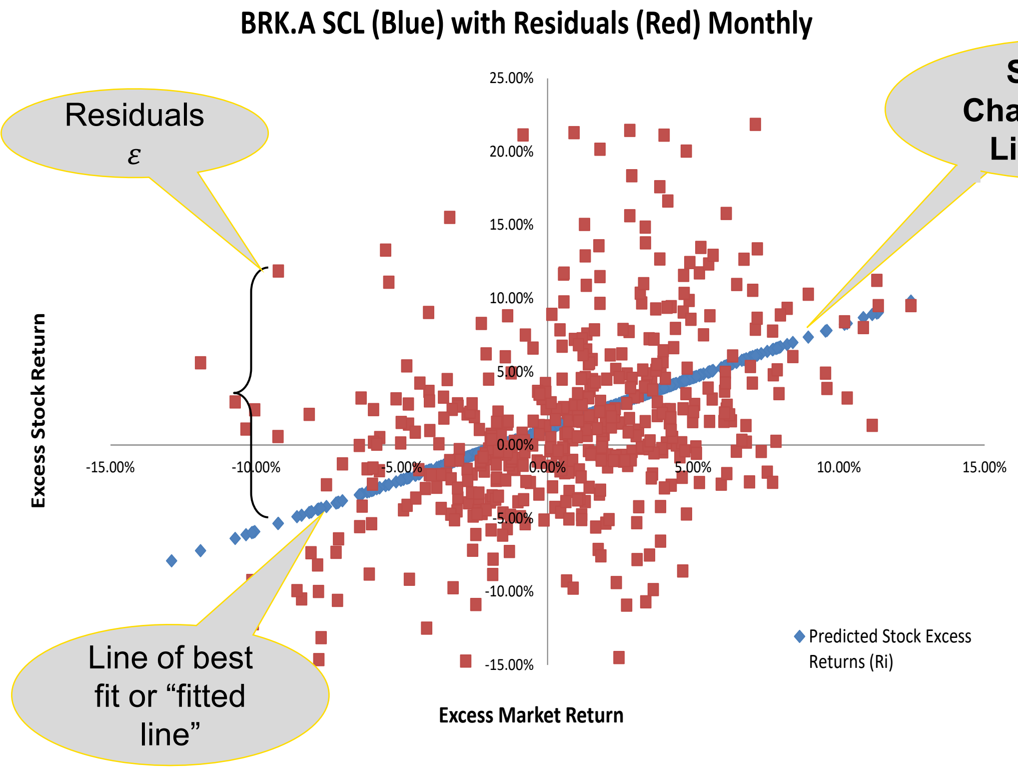
R^2 is the % of HP's movement explained by the market

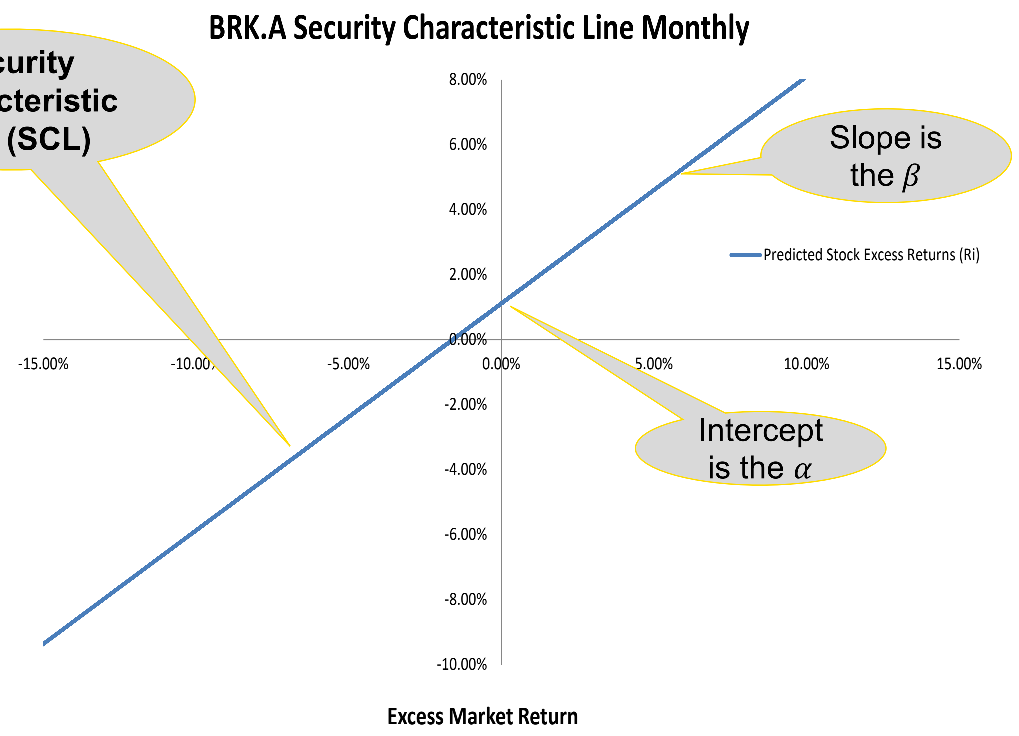
Significance testing of α and β

- The correlation between HP and the market is 0.72 and the market explains about 52% of the variation in HP (the R^2)
- HP's α is 0.86% per month (10.32% annually) but it is not statistically significant
- HP's β is 2.035 with a 95% confidence interval (+/- 1.96x standard error) of ≈1.54 - 2.53
- HP's α is not significant and the 95% confidence interval for it's β is between 1.54 - 2.53

Security Characteristic Line Example 2 - BRK

- **Example:** Using the monthly data from October 1976 to March 2017 (486 observations) plot the SCL for BRK by regressing monthly BRK excess returns against the monthly market excess returns. Interpret your results - is α and β significant, what does the R^2 indicate?
  - See excel file "Berkshire Hathaway SCL" or watch video for detailed steps in excel





BRK's SCL Regression Statistics Example 2

Regression Statistics	
Multiple R	0.444341315
R Square	0.197439205
Adjusted R Square	0.195781021
Standard Error	0.062203481
Observations	486

Correlation Coefficient

R^2 is the % of BRK's movement explained by the market

Significance testing of α and β

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept (α)	0.011130915	0.002849682	3.90602051	0.00010717	0.00553164	0.01673019
X Variable 1 (β)	0.698217453	0.063986786	10.91190074	6.18982E-25	0.572491261	0.823943644

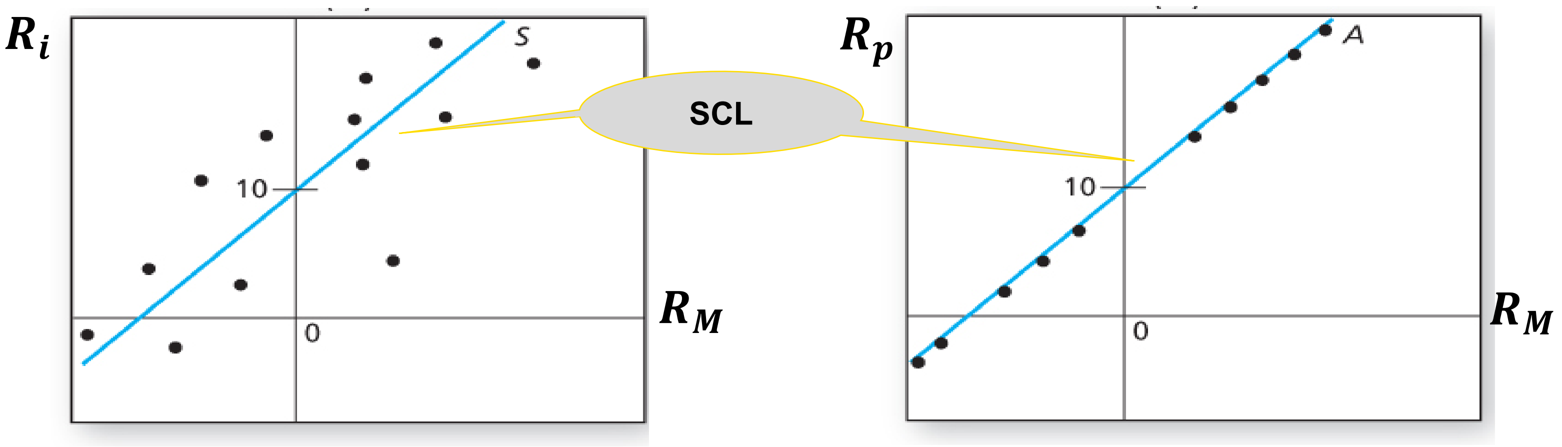
- The correlation between HP and the market is 0.44 and the market explains about 20% of the variation in BRK (the R^2)
- BRK's α is 1.11% per month (13.4% annually) and it is statistically significant at the 99% confidence interval
- BRK's β is 0.698 with a 95% confidence interval (+/- 1.96x standard error) of ≈0.57 – 0.82
- **BRK's α is significant and high and it's β is low** (95% confidence interval of 0.57 – 0.82)

SIM and Diversification

Unsystematic Risk Under SIM

- The SCL fitted line represents the systematic return component (due to market movements)
  - The residuals represent deviations from the predicted or expected return (the fitted line)
    - We categorise all of these deviations as firm-specific movements (unsystematic)
  - If the observations hug the fitted line, much of the asset's movement is caused by market movements (high R^2) and it's risk is mostly systematic. If the observations are dispersed, much of the asset's movement is firm-specific (a low R^2) and it's risk is mostly unsystematic
  - By grouping a number of stocks into a diversified portfolio, firm-specific movements offset each other, reducing unsystematic risk - the observations will hug the fitted line

Single Stock **Well Diversified Portfolio**



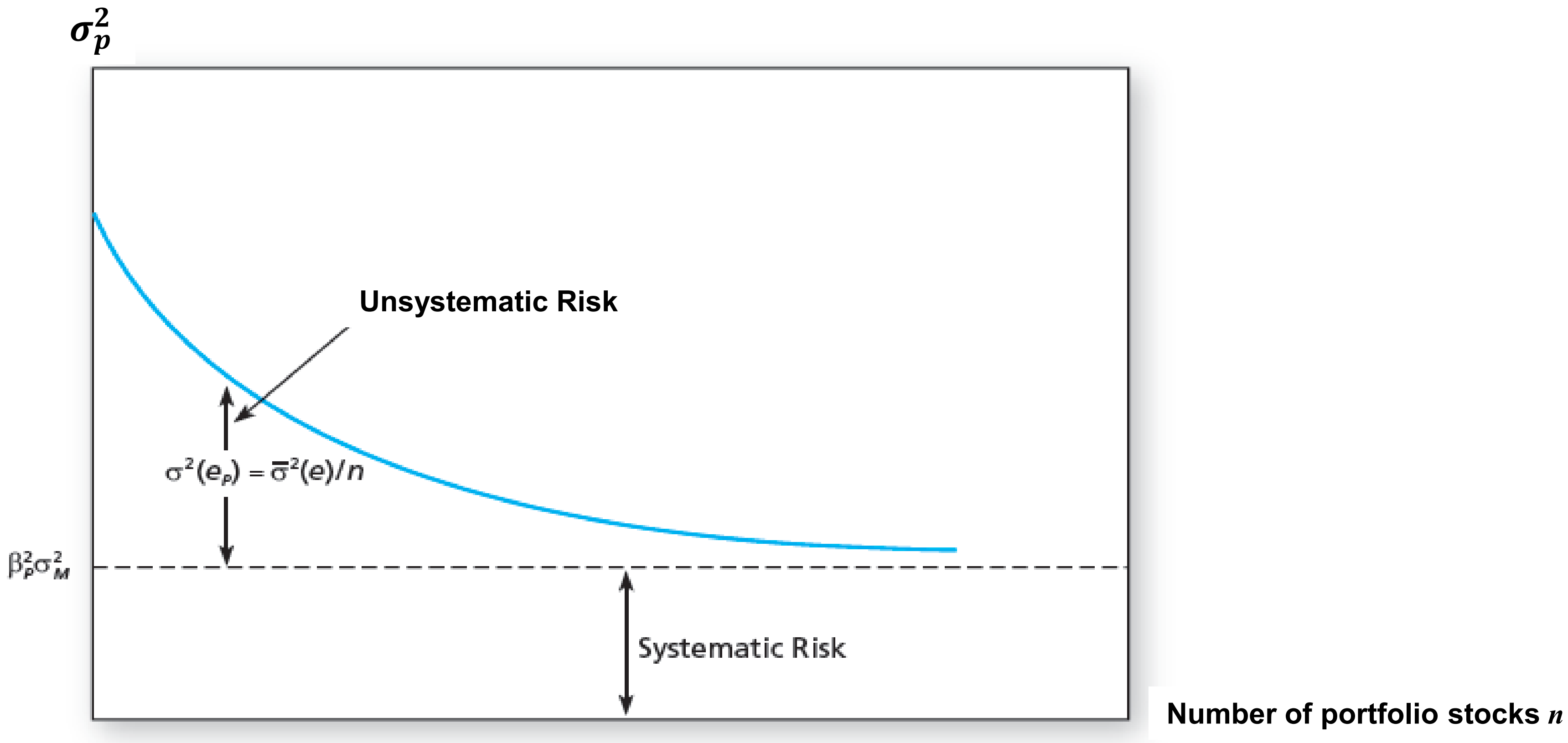
Unsystematic Risk Under SIM

- Lets see why unsystematic risk can almost be eliminated by a well diversified portfolio
- The residual (unsystematic) variance of an equally-weighted portfolio is given by:

$$\sigma_{\varepsilon_p}^2 = \frac{\sum_{i=1}^{n} \sigma_{\varepsilon_i}^2}{n^2}$$

- In other words, we add all the residual variances of each individual asset in our portfolio and rather than dividing by n, we divide by n^2 to obtain portfolio residual variance
  - When n gets large, $\frac{1}{n^2} \rightarrow 0$ and $\sigma_{\varepsilon_p}^2$ becomes negligible
  - Firm-specific (unsystematic) risk (measured by the residual variance) is diversified away
- The more assets in the portfolio, the more unsystematic risk is eliminated
  - Portfolio systematic risk will converge to market risk σ_M^2 as we add more assets, because portfolio β_p converges to 1 (from the equation discussed in 4.2: $\sigma_p^2 = \beta_p^2\,\sigma_M^2 + \sigma_{\varepsilon_p}^2$)

Unsystematic Risk Falls With Diversification



- A portfolio of around 25-30 uncorrelated stocks almost fully eliminates unsystematic risk
- From BKM Figure 8.2