Portfolio Risk and Return

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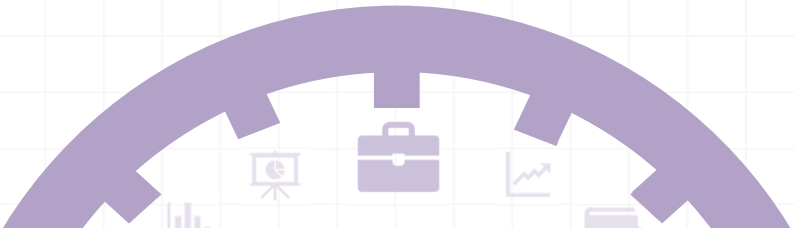

Portfolio Risk Measures (Recap)

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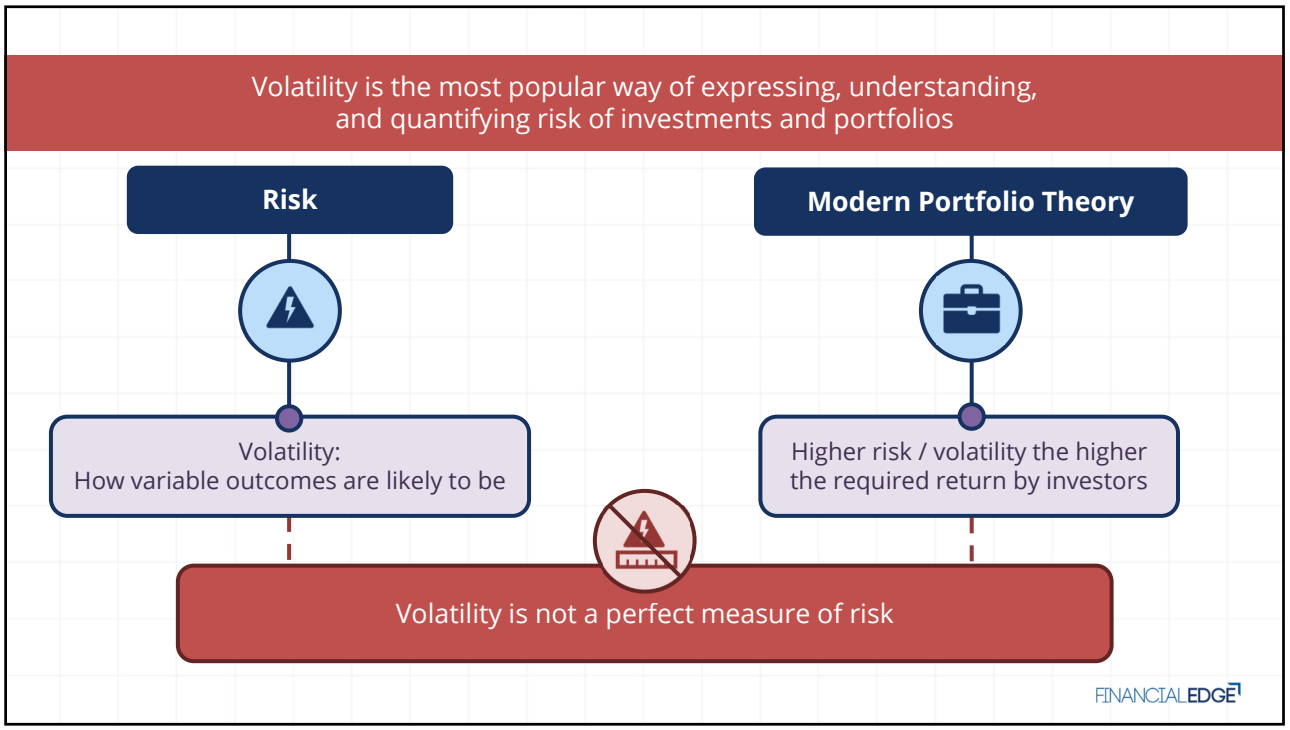
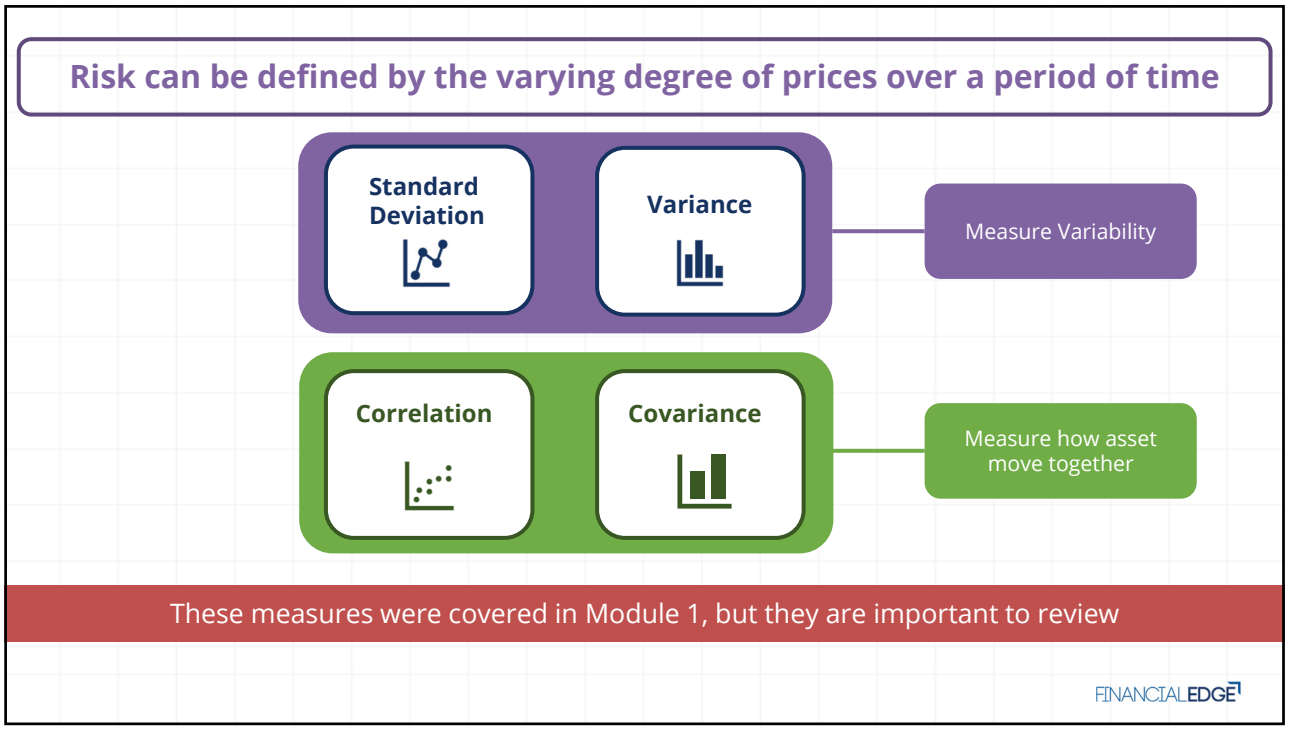
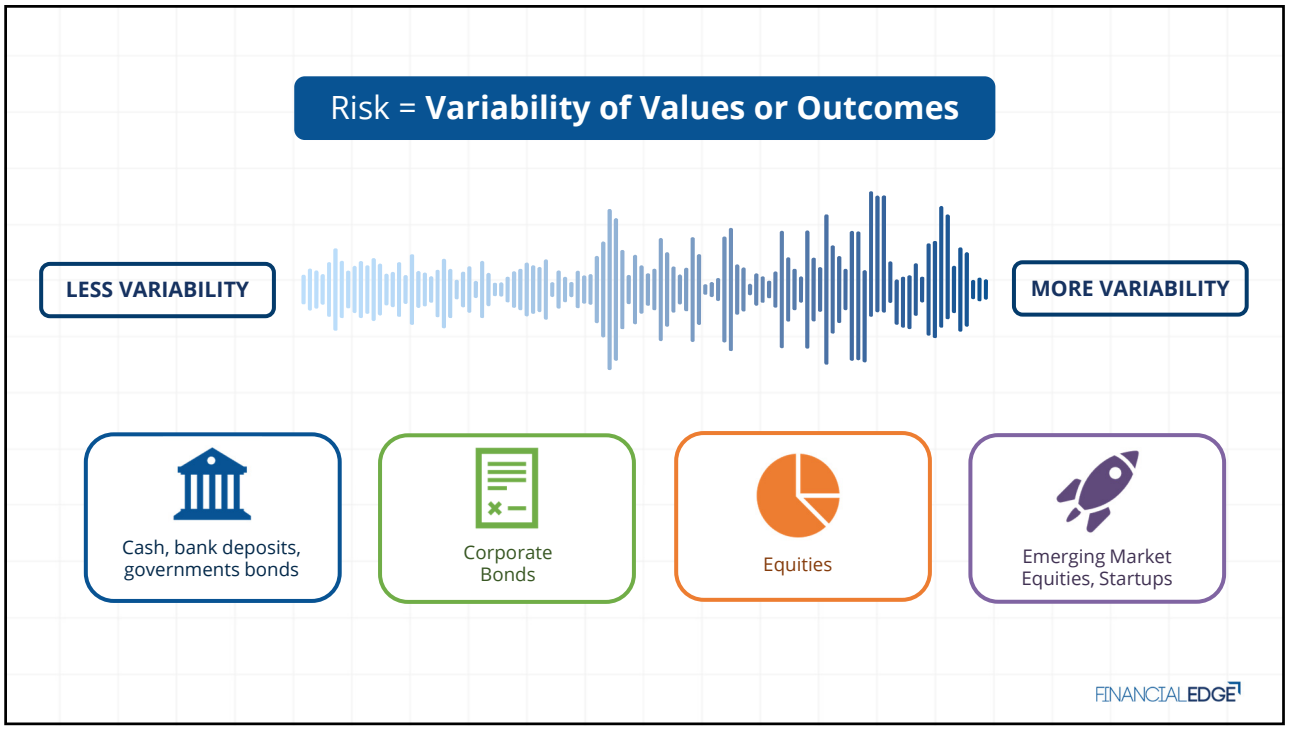
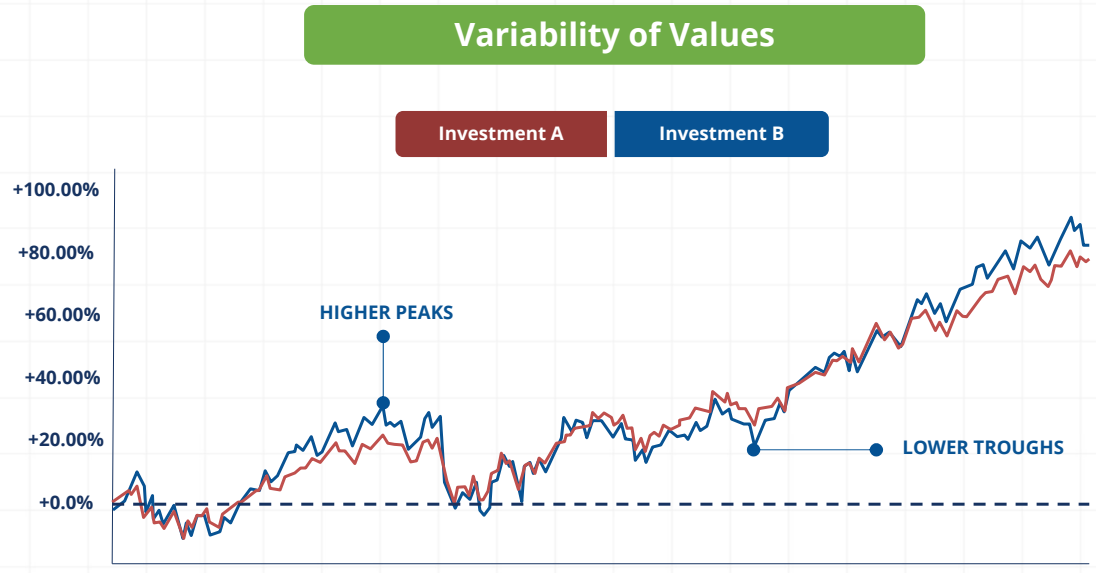






Variability of Values



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Asset Variability (1926 – 2019)

	COMPOUND ANNUAL RETURN	ARITHMETIC ANNUAL RETURN	RISK (STANDARD DEVIATION)	RETURN DISTRIBUTION
SMALL STOCKS*	11.9%	16.3%	28.1%	
LARGE STOCKS	10.2%	12.1%	18.6%	
GOVERNMENT BONDS	5.5%	6.0%	8.5%	
TREASURY BILLS	3.3%	3.4%	0.9%	

MORE VARIABILITY HIGHER RISK

MORE VARIABILITY HIGHER RISK

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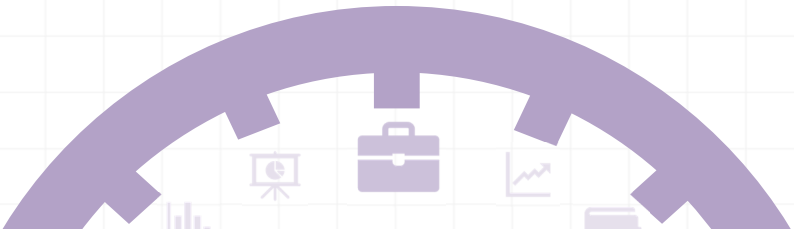

Components of Risk

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The **risk associated with any asset or security** has two components

TOTAL RISK =  + 

SYSTEMATIC RISK **UNSYSTEMATIC RISK**

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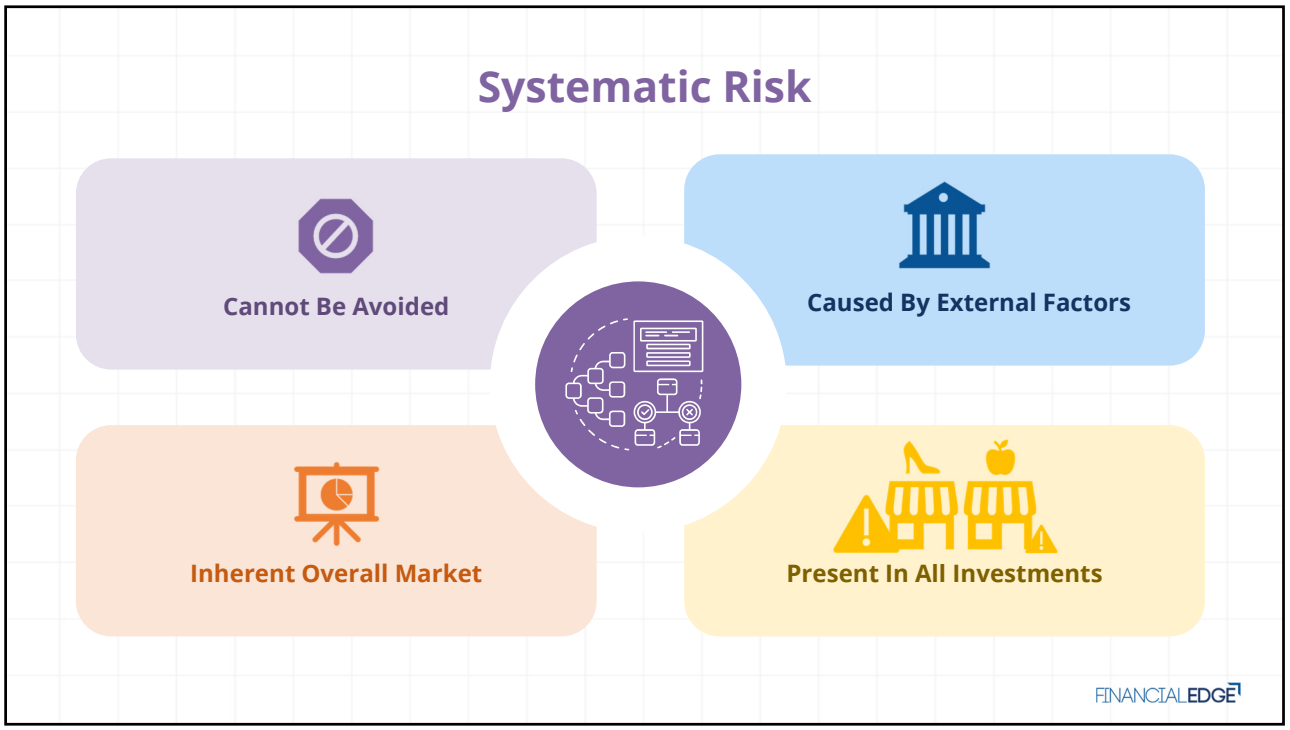

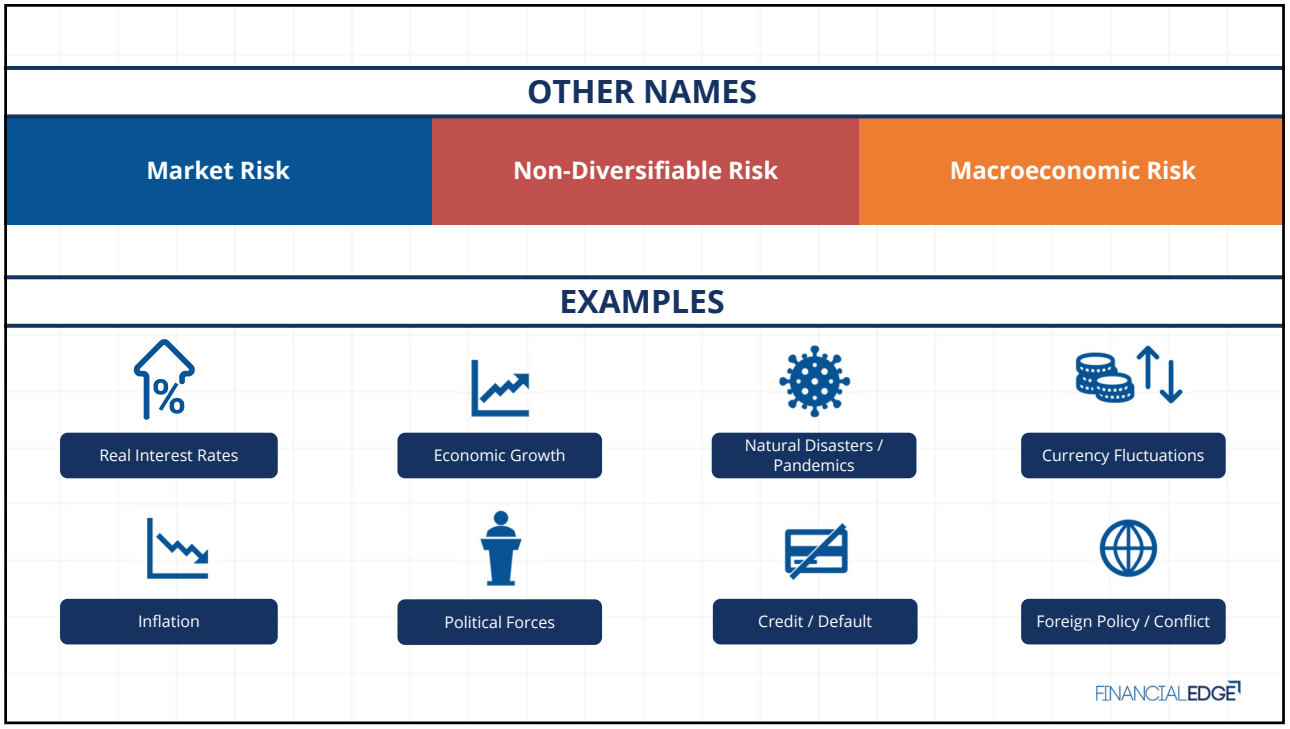

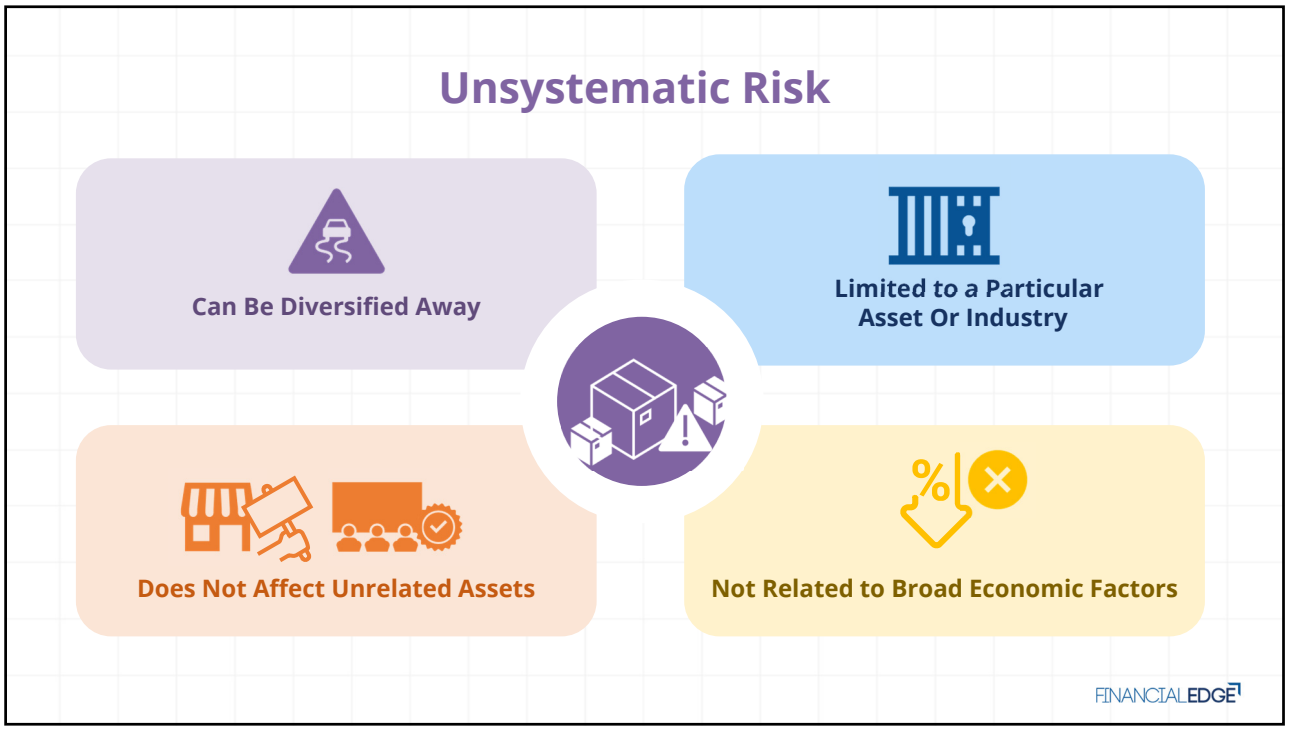

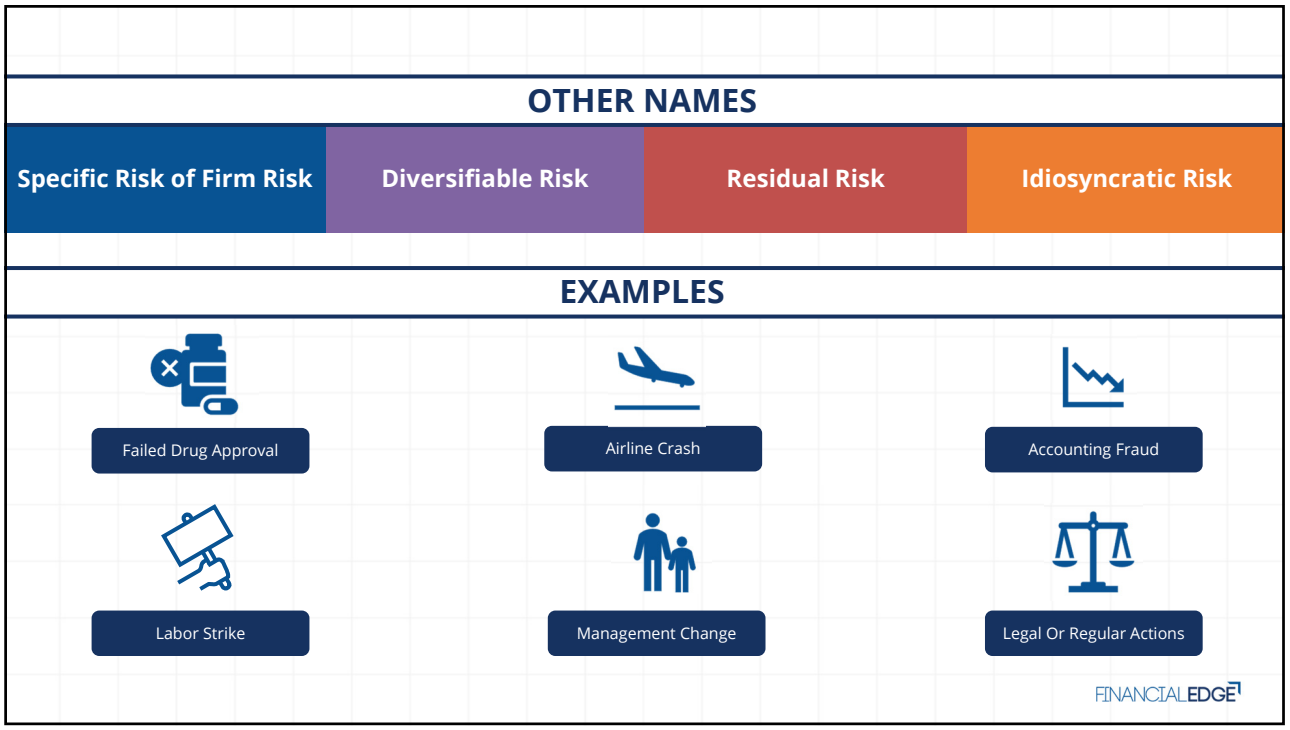

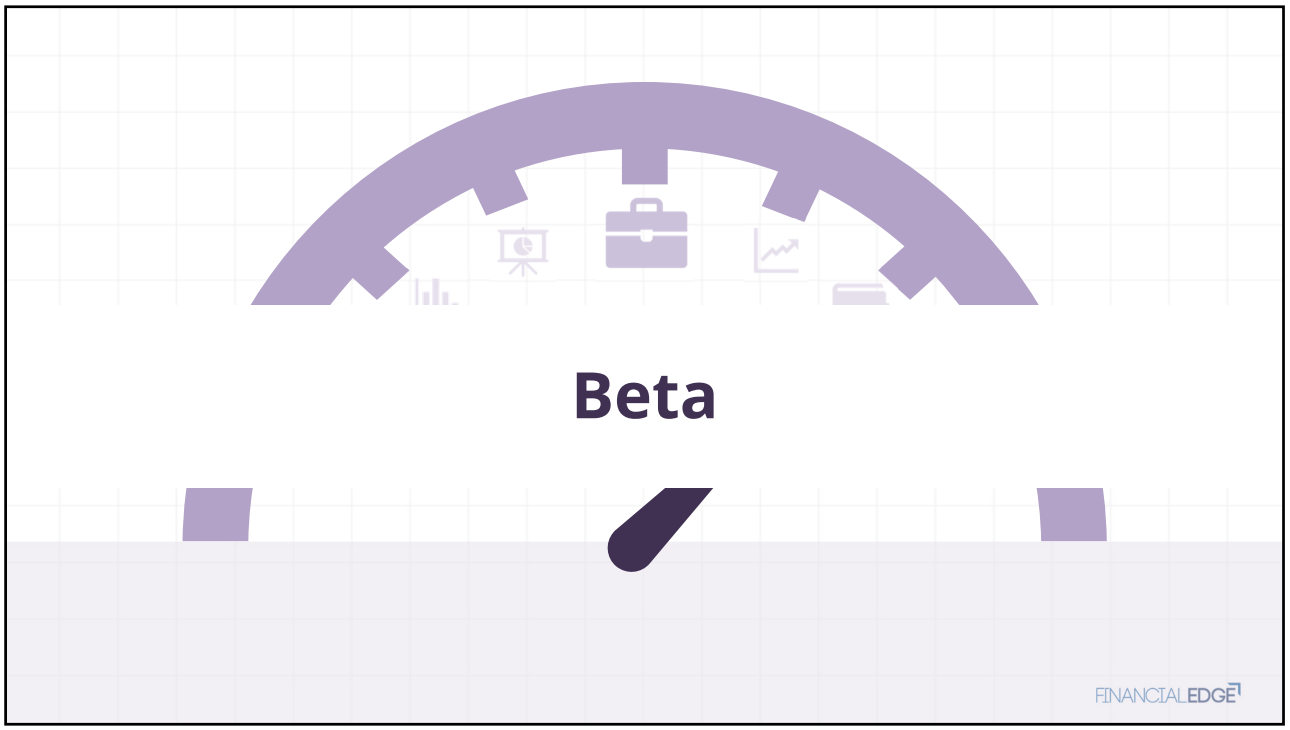

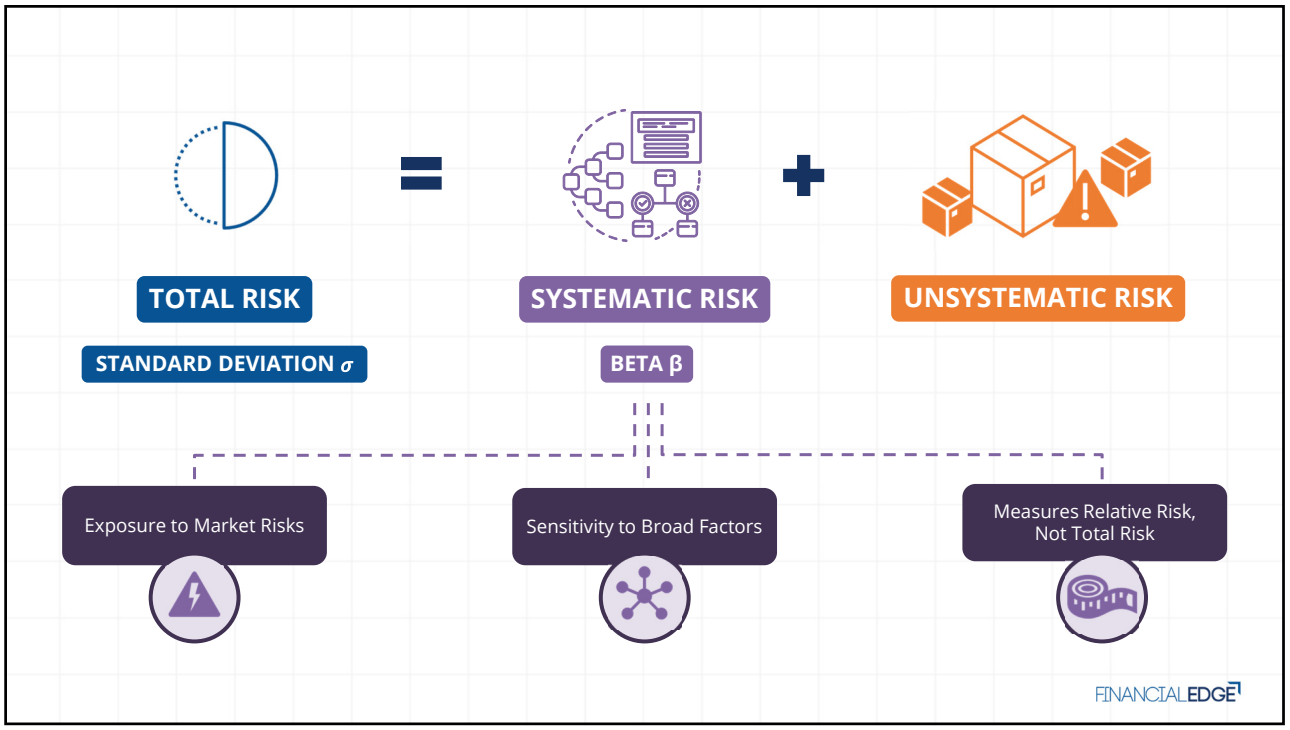

Interpreting Beta

Beta for the market = 1

Example

Market return (above risk free rate) = 10%

Asset Beta = 1.4

Asset Return = 1.4 x 10% = 14% (above risk free rate)

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Interpreting Beta

Beta for the market = 1

Example

Market return (above risk free rate) = 10%

Asset Beta = 0.8

Asset Return = 0.8 x 10% = 8% (above risk free rate)

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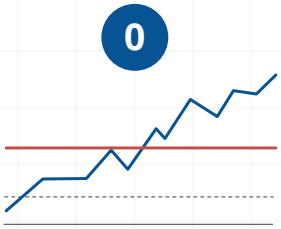
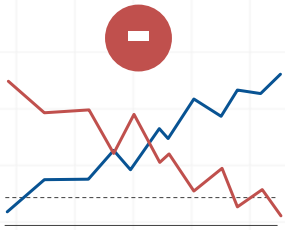
Interpreting Beta

Asset tends to move in the **same direction** and the **same percentage as the market**



Uncorrelated to the **market**
No systematic risk



The asset tends to move in the **opposite direction**
Inverse relationship

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Interpreting Beta

Sector	Beta (5 Year)
S&P 500	1.0
Utilities	0.5
Consumer Staples	0.6
Communication Services	0.8
Health Care	0.8
Real Estate	0.8

Sector	Beta (5 Year)
Information Technology	1.0
Consumer Discretionary	1.1
Energy	1.6

Sectors that are less sensitive to the macroeconomic environment tend to have lower systematic risk and therefore lower betas

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Interpreting Beta

Sector	Beta (5 Year)
S&P 500	1.0
Utilities	0.5
Real Estate	0.8

Sectors that are more sensitive to the macroeconomic environment tend to have higher systematic risk and therefore higher betas

Sector	Beta (5 Year)
Information Technology	1.0
Consumer Discretionary	1.1
Industrials	1.2
Materials	1.2
Financials	1.3
Energy	1.6

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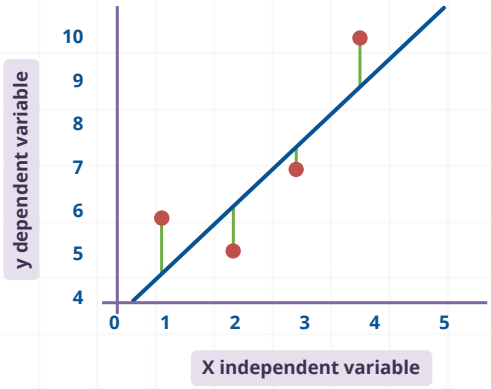
Estimating Beta

Regression analysis is the most common estimation method



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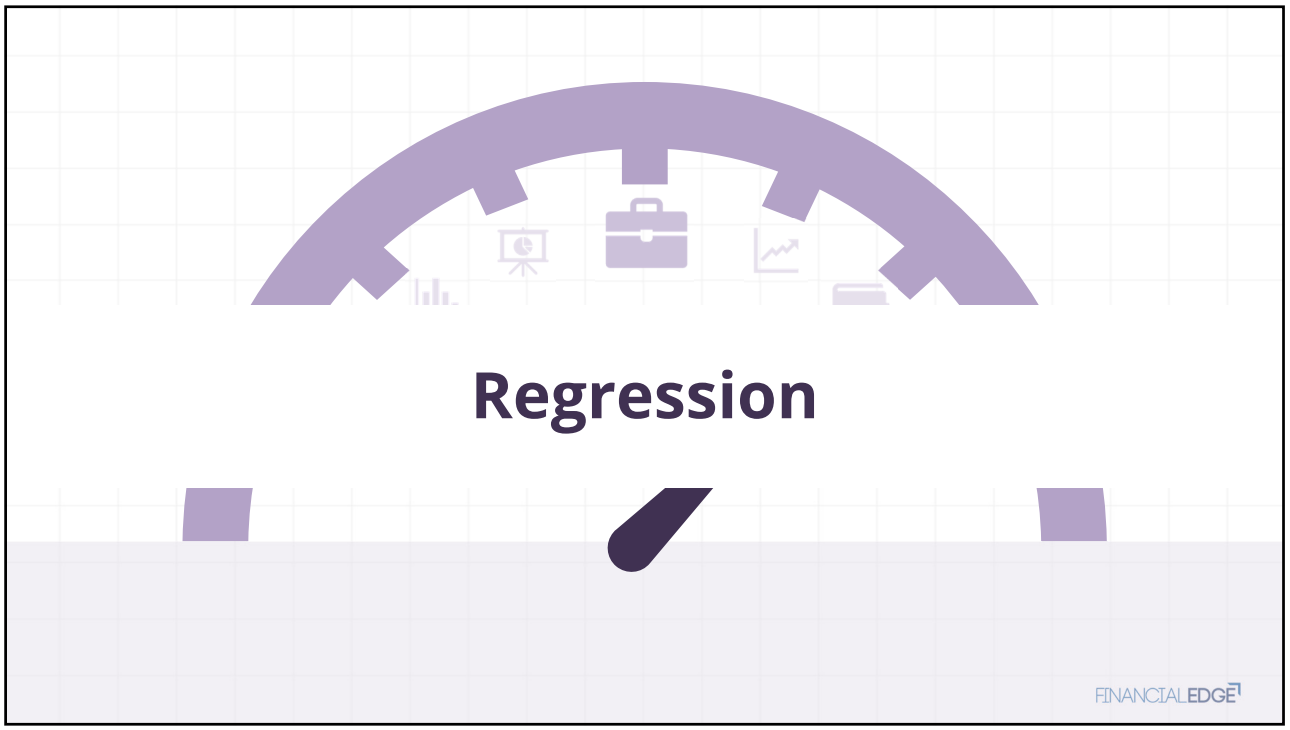

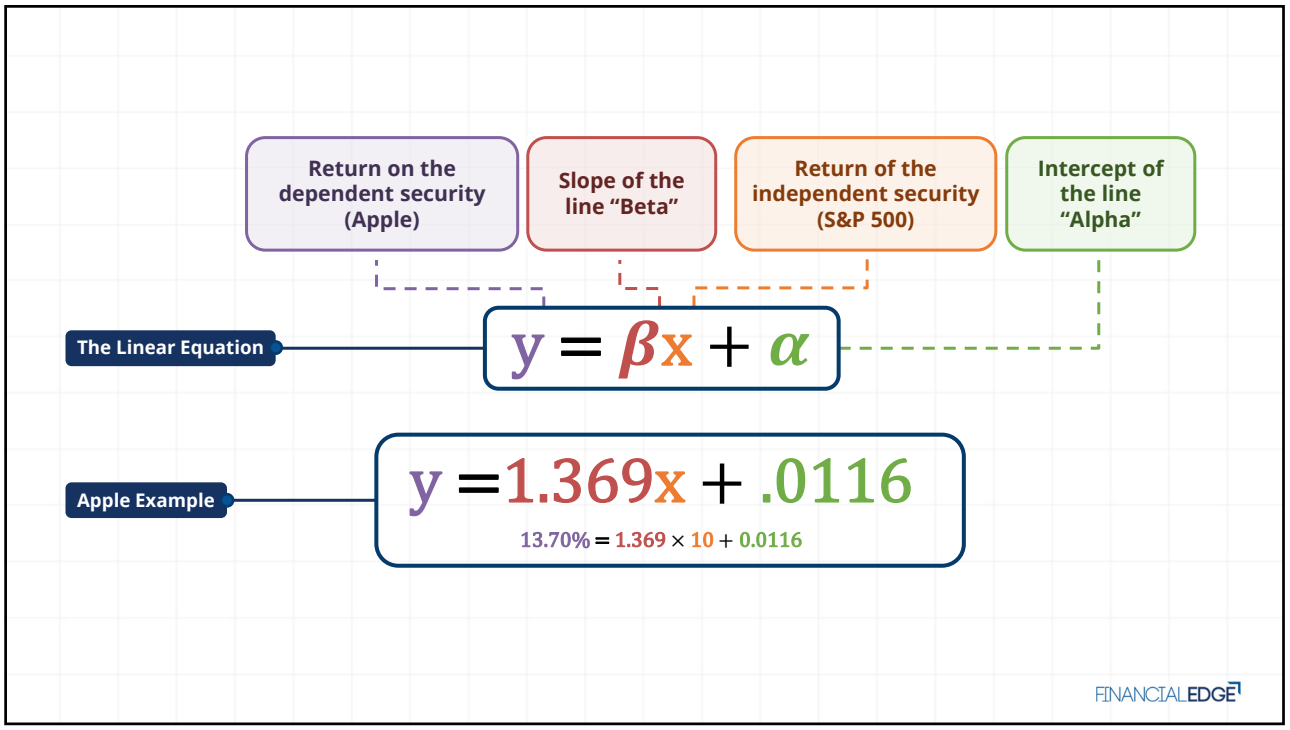

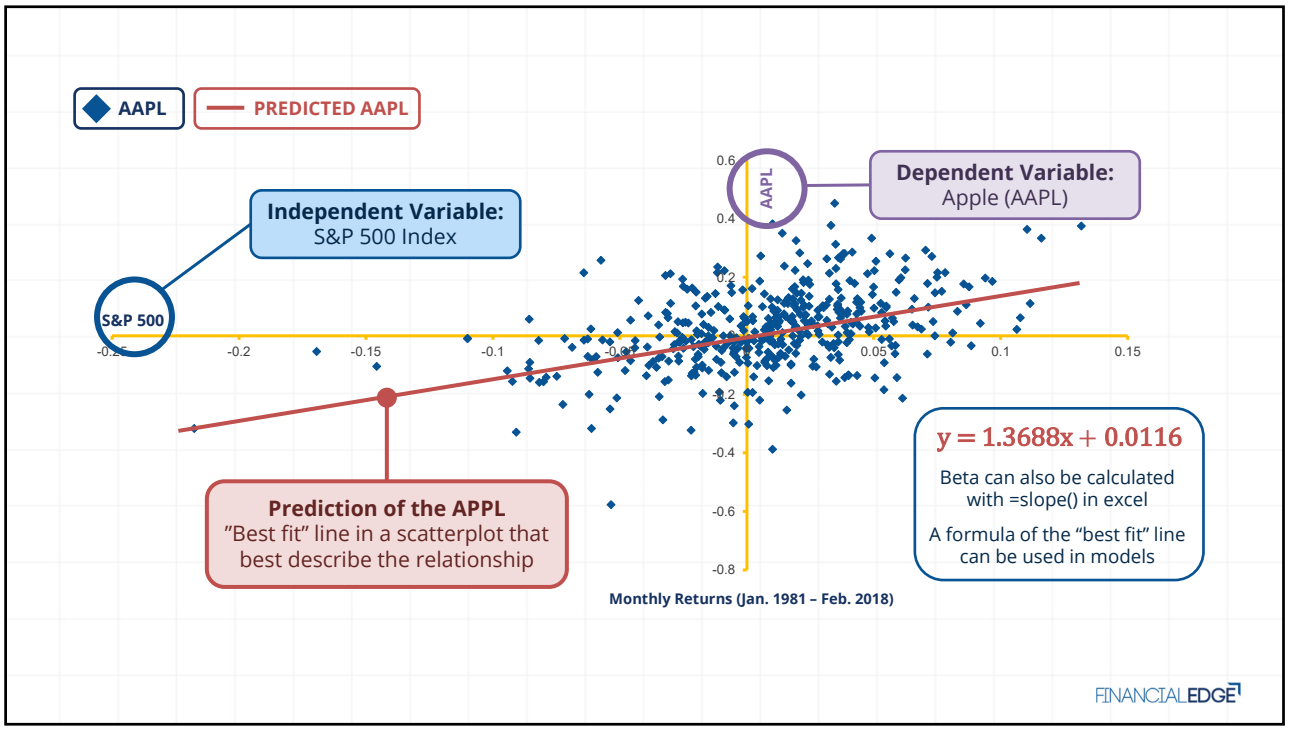

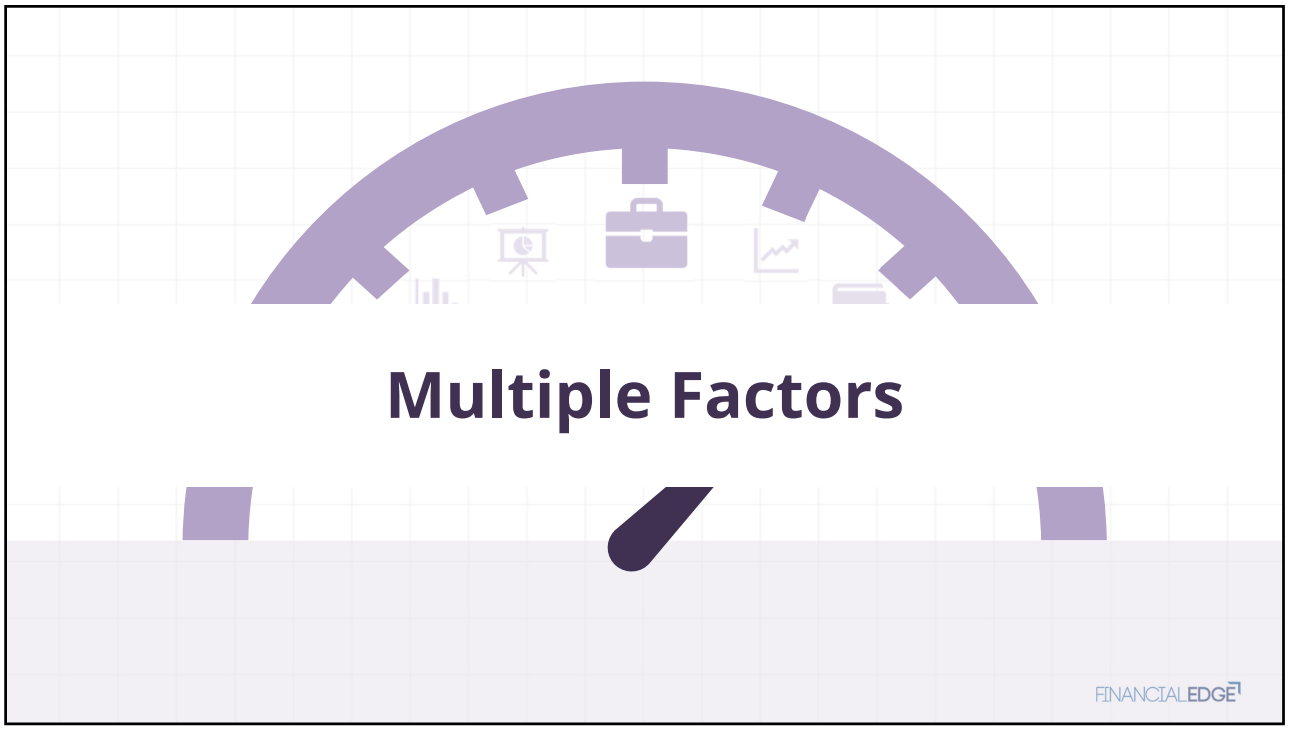

MACROECONOMIC	FUNDAMENTAL	STATISTICAL

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MACROECONOMIC	FUNDAMENTAL	STATISTICAL

Economic Growth
Real Interest rates
Inflation Etc.

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MACROECONOMIC	FUNDAMENTAL	STATISTICAL
		
Economic Growth Real Interest rates Inflation Etc.	Security specific data: earnings, cash flow, valuation, size Etc.	

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MACROECONOMIC	FUNDAMENTAL	STATISTICAL
		
Economic Growth Real Interest rates Inflation Etc.	Security specific data: earnings, cash flow, valuation, size Etc.	Statistical patterns or relationships

Return on the dependent security

$$y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \alpha$$

1st Variable | 2nd Variable | 3rd Variable | Risk Free Rate

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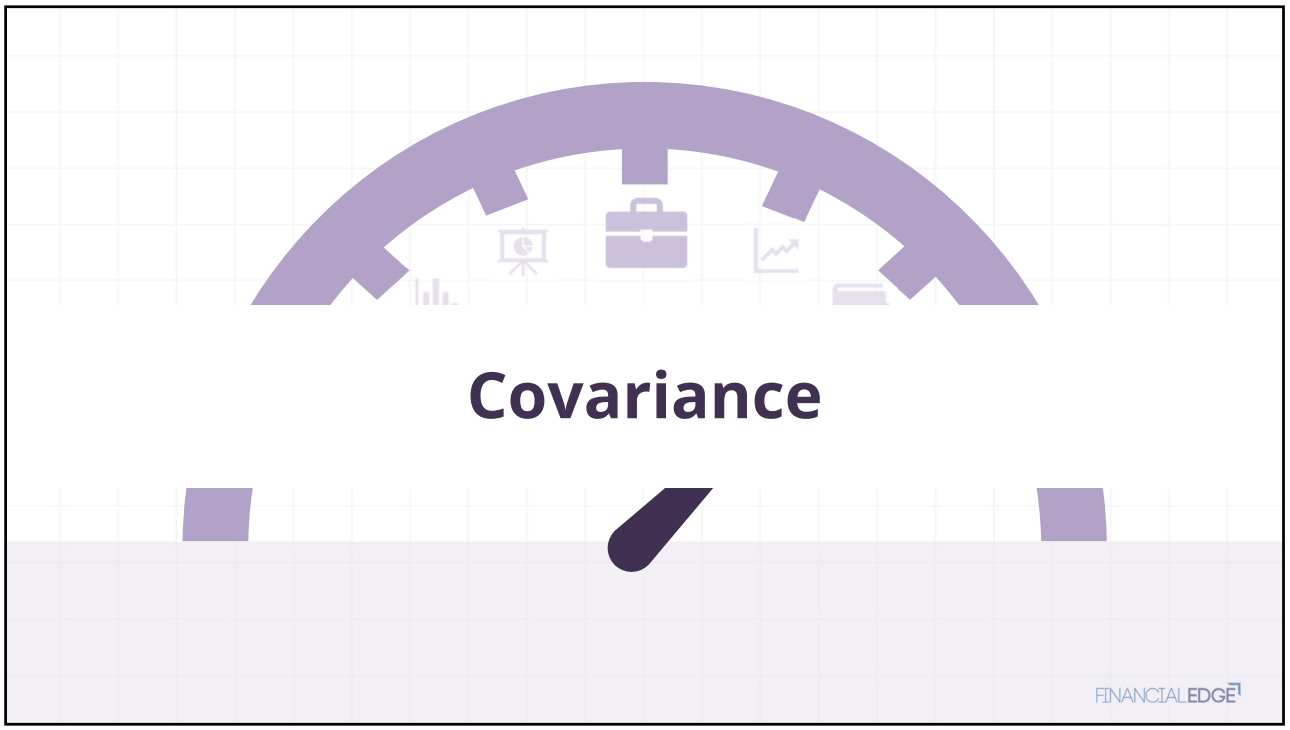

A measure of **how the returns on two assets move or do not move in same direction**

$$Cov(X,Y) = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{(n-1)}$$

> 0 = **Positive Relationship**

< 0 = **Negative Relationship**

But **units make it difficult** to interpret the **strength of the relationship**

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Example 1 – Microsoft

	A	B	C	D	E	F	G	H	I
1		Return on	Return on						
2		SP50	MSFT	SP50 var.		MSFT var.		Product	
3	01/01/2019								
4	01/02/2019	7.9	2.8	5.9	=B4-B$10	(1.5)	=C4-C$10	(8.8)	=D4*F4
5	01/03/2019	3.0	7.7	1.0	=B5-B$10	3.4	=C5-C$10	3.3	=D5*F5
6	01/04/2019	1.8	5.3	(0.2)	=B6-B$10	1.0	=C6-C$10	(0.2)	=D6*F6
7	01/05/2019	3.9	10.7	1.9	=B7-B$10	6.4	=C7-C$10	12.4	=D7*F7
8	01/06/2019	(6.6)	(4.9)	(8.6)	=B8-B$10	(9.3)	=C8-C$10	79.5	=D8*F8
9									
10	Mean	2.0	4.3	=AVERAGE(C4:C8)					
11	Sum of product							86.2	=SUM(H4:H8)
12	Number of observations -1							4.0	=COUNT(H4:H8)-1
13	Covariance							21.5	=H11/H12

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Example 2 – Franco Nevada Corp

	A	B	C	D	E	F	G	H	I
1		Return on	Return on						
2		SP50	FNV	SP50 var.		FNV var.		Product	
3	01/01/2019								
4	01/02/2019	7.9	10.6	5.9	=B4-B$10	8.5	=C4-C$10	49.8	=D4*F4
5	01/03/2019	3.0	(2.9)	1.0	=B5-B$10	(5.1)	=C5-C$10	(4.9)	=D5*F5
6	01/04/2019	1.8	(0.1)	(0.2)	=B6-B$10	(2.3)	=C6-C$10	0.5	=D6*F6
7	01/05/2019	3.9	(4.5)	1.9	=B7-B$10	(6.7)	=C7-C$10	(12.9)	=D7*F7
8	01/06/2019	(6.6)	7.7	(8.6)	=B8-B$10	5.5	=C8-C$10	(47.4)	=D8*F8
9									
10	Mean	2.0	2.2	=AVERAGE(C4:C8)					
11	Sum of product							(14.9)	=SUM(H4:H8)
12	Number of observations -1							4.0	=COUNT(H4:H8)-1
13	Covariance							(3.7)	=H11/H12

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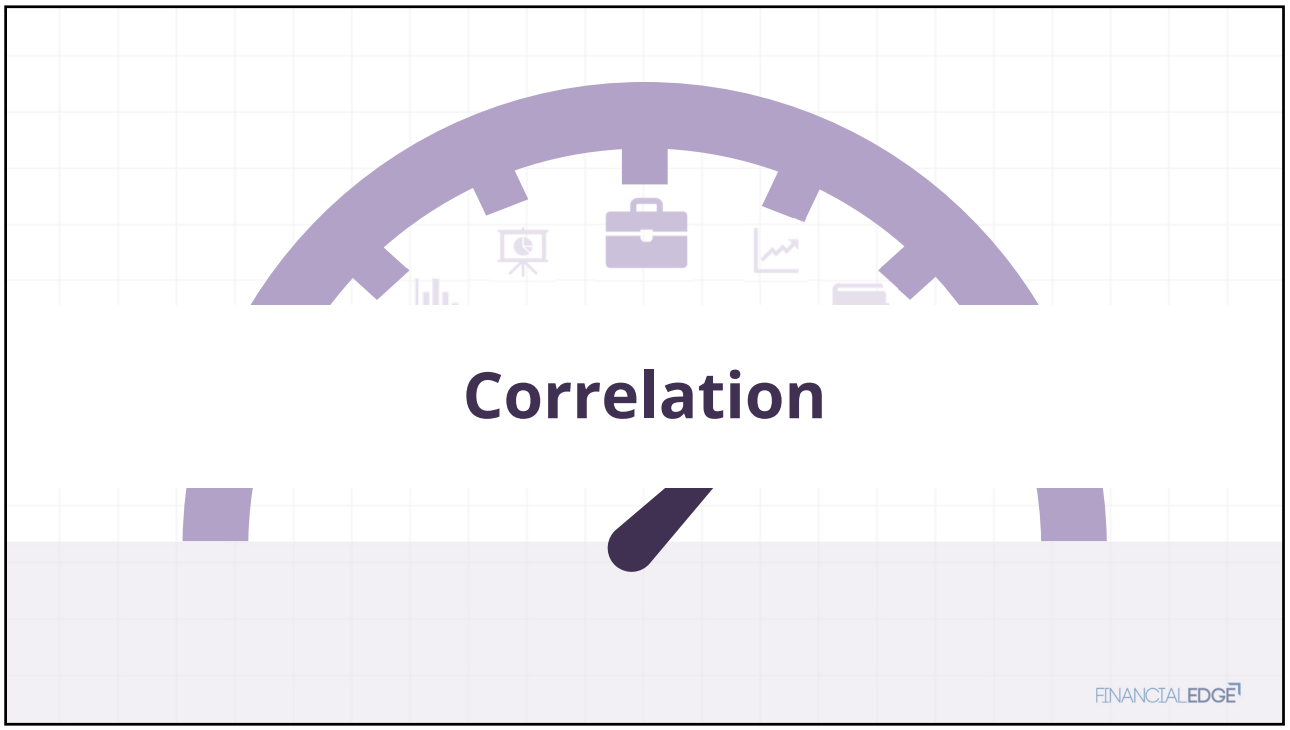

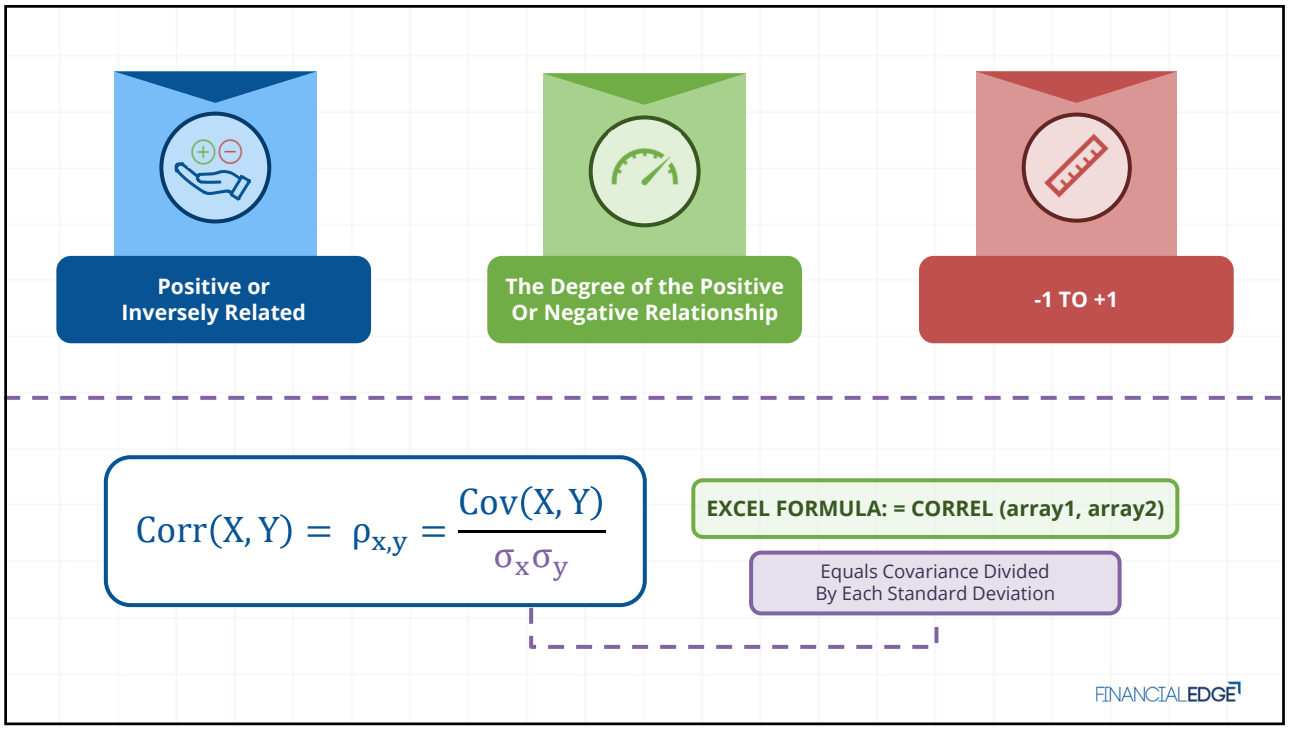

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6	01/04/2019	1.8	5.3	(0.2)	=B6-B$10	1.0	=C6-C$10	(0.2)	=D6*F6
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11	Sum of product							86.2	=SUM(H4:H8)
12	Number of observations -1							4.0	=COUNT(H4:H8)-1
13	Covariance							21.5	=H11/H12
14	Std dev.	5.3	6.0	=STDEV.S(C4:C8)					
15	Correlation							0.68	=H13/(B14*C14)

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Example 2 – Franco Nevada Corp

	A	B	C	D	E	F	G	H	I
1		Return on	Return on						
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14	Std dev.	5.3	6.7	=STDEV.S(C4:C8)					
15	Correlation							(0.11)	=H13/(B14*C14)

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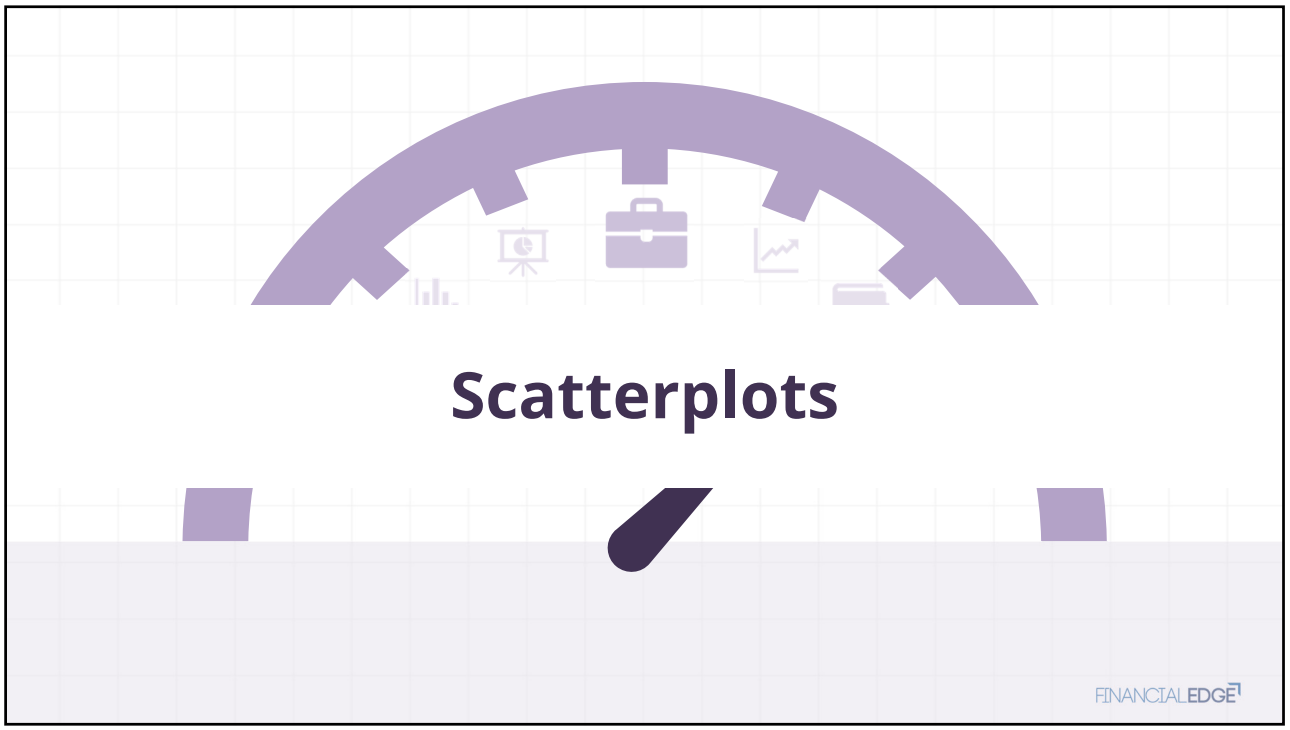

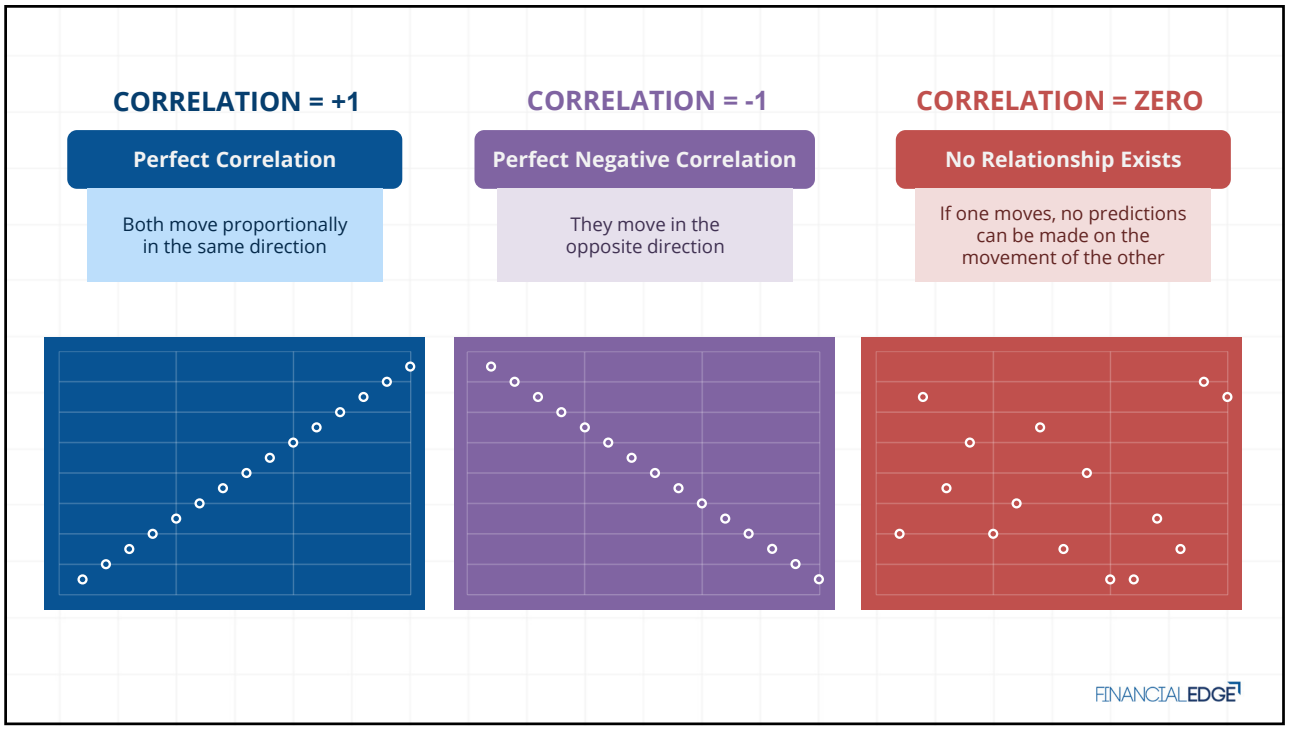

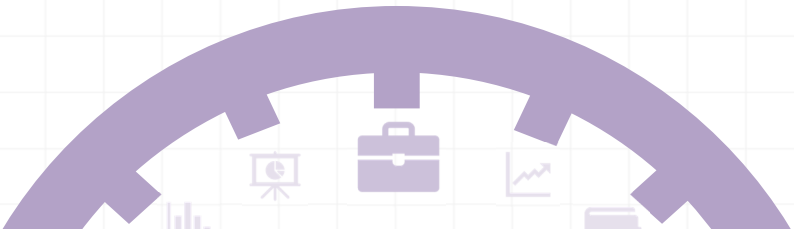

Correlation – Other Key Points

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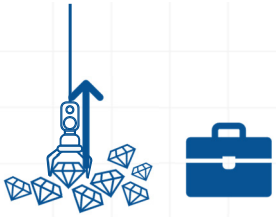

What Asset Will Increase Portfolio Diversification

The lower the correlation, the more diversification benefits

There are no diversification benefits if the correlation is +1

Correlation Does Not Equal Causation

Snow boots and car accidents have a correlation, but snow boots do not cause car accidents

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Correlation Matrix

ASSET-CLASS CORRELATIONS 1926–2015

	Small Stocks	Large Stocks	LT Corp Bonds	LT Gov Bonds	IT Gov Bonds	Treasury Bills
Small Stocks	1.00					
Large Stocks	0.80	1.00				
LT Corp Bonds	0.04	0.15	1.00			
LT Gov Bonds	-0.10	0.00	0.90	1.00		
IT Gov Bonds	-0.11	-0.03	0.86	0.86	1.00	
Treasury Bills	-0.08	-0.02	0.16	0.18	0.47	1.00

Source: Morningstar

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Factor Correlations

Active Return Correlations for MSCI Factor Indexes since 1975

	Size	Yield	Momentum	Quality	Value	Low Volatility
Size	1.00					
Yield	0.26	1.00				
Momentum	-0.11	-0.03	1.00			
Quality	-0.19	0.40	0.22	1.00		
Value	0.60	0.48	-0.06	0.10	1.00	
Low Volatility	0.12	0.44	0.11	0.19	-0.03	1.00

Factors have generally had **low correlations with each other** and tended to **perform well at different parts of the economic cycle**

A **diversified strategy** can navigate more types of market environments and potentially **lower overall volatility**

Correlations of active returns relative to MSCI World, Monthly data, 30 Nov 1975 to 28 Feb 2018

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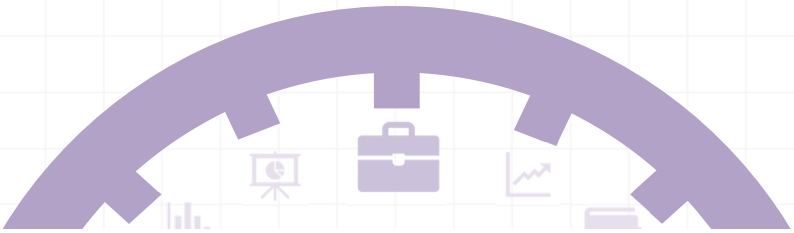

Correlation and Risk

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Calculating Standard Deviation (Total Risk) of a Two Asset Portfolio

$$\text{Stan Dev}_P = \sigma_P = \sqrt{\sigma_1^2 w_1^2 + \sigma_2^2 w_2^2 + 2 w_1 w_2 \text{Cor}_{(1,2)} \sigma_1 \sigma_2}$$

- Variance of each asset
- Multiplied by each of the weightings squared
- Correlation: measures how assets move in relation to each other

Easier to compare and interpret than variance alone

$$Stan\ Dev_P = \sqrt{Variance} \qquad \sigma_P = \sqrt{\sigma^2}$$

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Correlations and Risk Example 1 - Microsoft

	A	B	C	D	E	F	G	H	I
10	Mean	2.0	4.3	=AVERAGE(C4:C8)					
11	Sum of product							86.2	=SUM(H4:H8)
12	Number of observations -1							4.0	=COUNT(H4:H8)-1
13	Covariance							21.5	=H11/H12
14	Std dev.	5.3	6.0	=STDEV.S(C4:C8)					
15	Correlation							0.68	=H13/(B14*C14)
16	Weight	50.0%	50.0%						
17	Weighted deviation squared	7.0	8.9	=C16^2*C14^2					
18	Sum of the weighted deviation			15.9	=C17+B17				
19	Correlation factor			10.8	=2*H15*B16*C16*B14*C14				
20	Variance			26.7	=D18+D19				
21	Portfolio standard deviation			5.2	=D20^0.5				

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Correlations and Risk Example 2 - FNV

	A	B	C	D	E	F	G	H	I
10	Mean	2.0	2.2	=AVERAGE(C4:C8)					
11	Sum of product							(14.9)	=SUM(H4:H8)
12	Number of observations -1							4.0	=COUNT(H4:H8)-1
13	Covariance							(3.7)	=H11/H12
14	Std dev.	5.3	6.7	=STDEV.S(C4:C8)					
15	Correlation							(0.11)	=H13/(B14*C14)
16	Weight	50.0%	50.0%						
17	Weighted deviation	7.0	11.1	=C16^2*C14^2					
18	Sum of the weighted deviation			18.1	=C17+B17				
19	Correlation factor			(1.9)	=2*H15*B16*C16*B14*C14				
20	Variance			16.3	=D18+D19				
21	Portfolio standard deviation			4.0	=D20^0.5				

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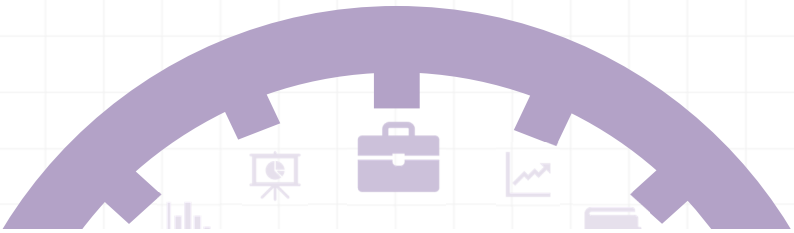

Diversification Effect

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$$\text{Stan Dev}_P = \sigma_P = \sqrt{\sigma_1^2 w_1^2 + \sigma_2^2 w_2^2 + 2 w_1 w_2 \text{Corr}_{(1,2)} \sigma_1 \sigma_2}$$

Perfect Positive Correlation =1	$\sigma_P = \sigma_1 = \sigma_2$	No benefits from diversification
-1< Correlation < +1	Stan Dev of portfolio will be less than weighted average of assets	Diversification benefits increase as correlation declines
Perfect Negative Correlation = -1	A perfect hedge $\sigma\_P = 0$	Stan Dev of the Portfolio is zero: risk free

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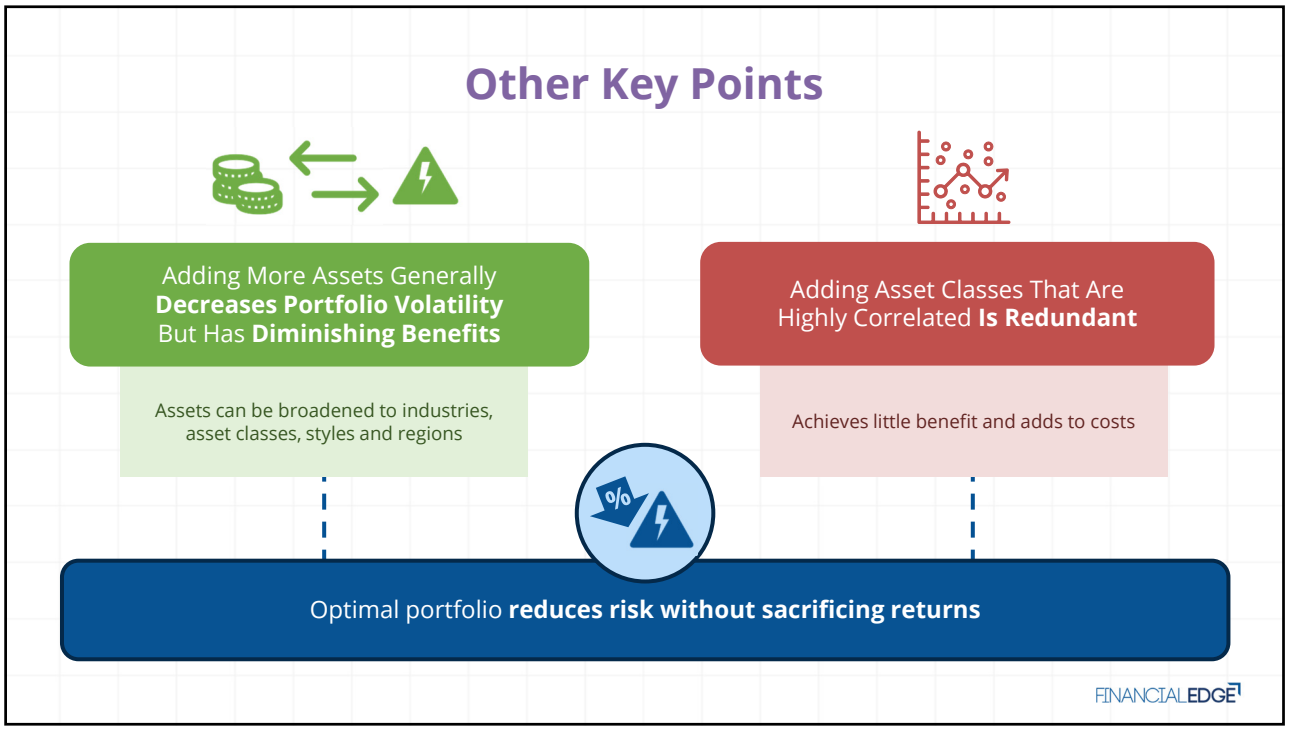

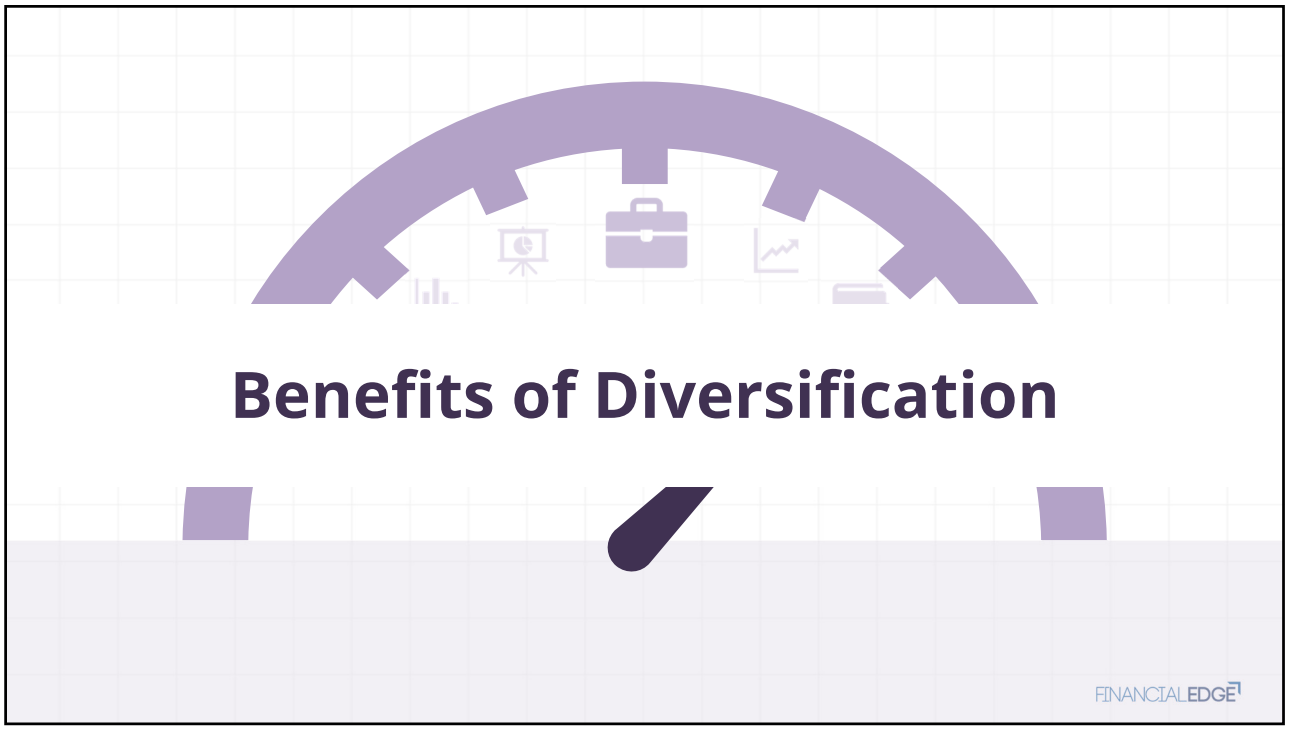

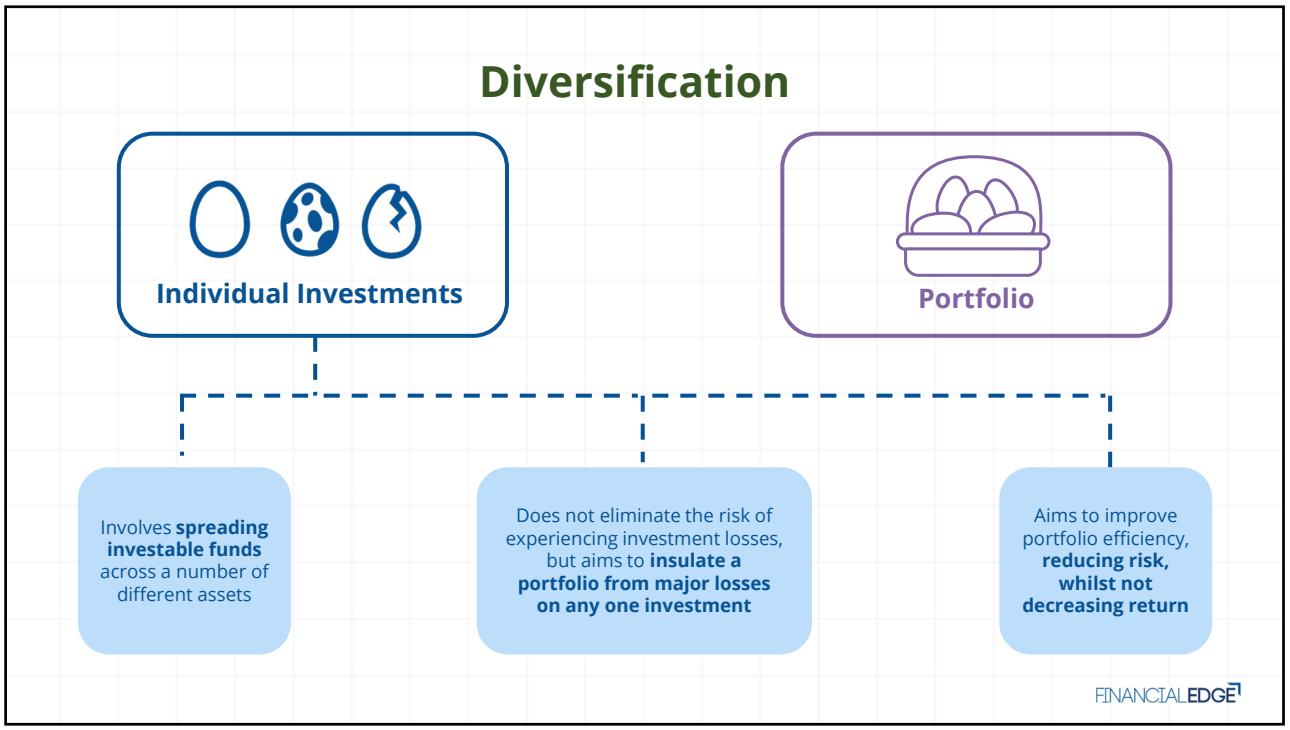

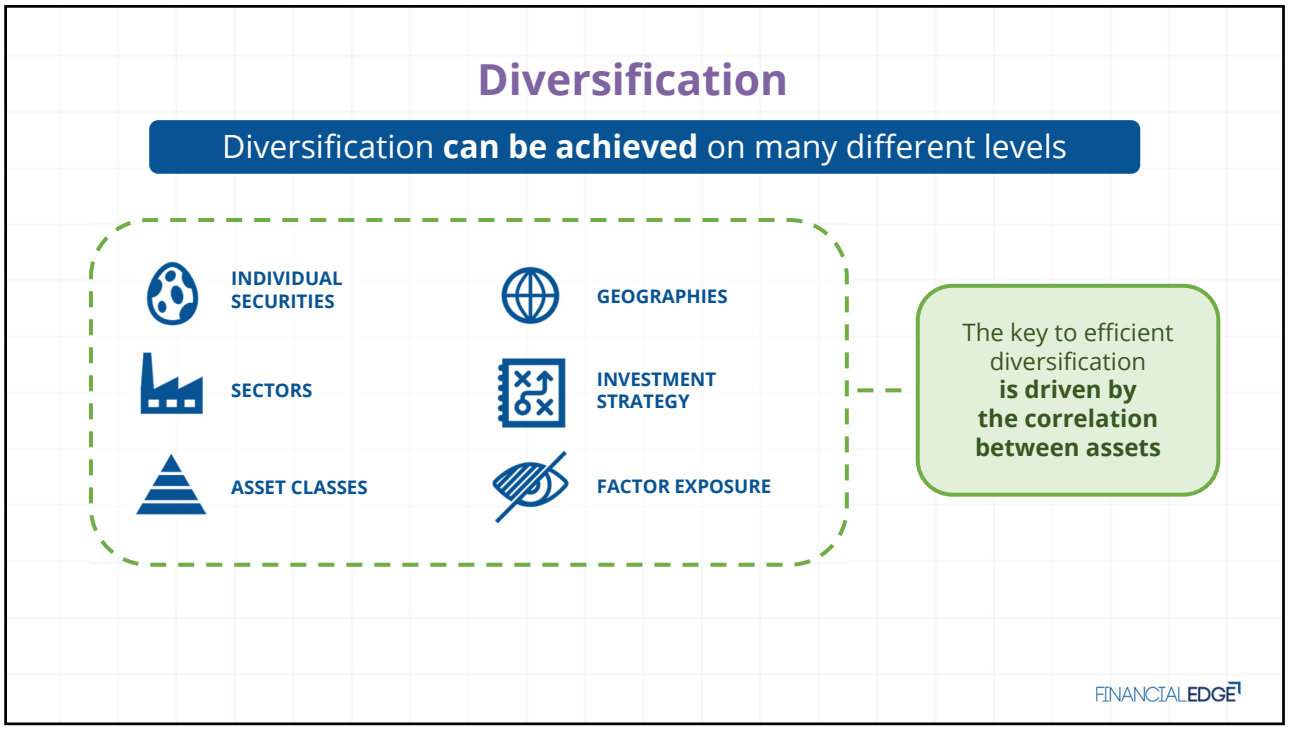

Diversification Examples

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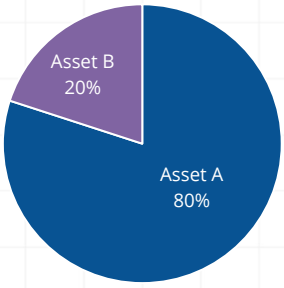
Example: Two Asset Portfolio

Assume An Investor Holds A Portfolio With The Following Weights



	EXPECTED RETURN	RISK (Standard Deviation)
Asset A	10%	16%
Asset B	18%	33%

CORRELATION MATRIX

	Asset A	Asset B
Asset A	1	0.1
Asset B	0.1	1

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PORTFOLIO EXPECTED RETURN

$$= \text{Expected return(A)} \times \text{Weight (A)} + \text{Expected return(B)} \times \text{Weight (B)}$$

$$= 10\% \times 0.8 + 18\% \times 0.2$$

$$= 11.6\%$$

Simple weighted average of expected returns

PORTFOLIO RISK

$$= \sqrt{\sigma_1^2 w_1^2 + \sigma_2^2 w_2^2 + 2 w_1 w_2 \text{Cor}_{(1,2)} \sigma_1 \sigma_2}$$

Not just the weighted average of standard deviations

We need to take into account how the assets move together, i.e. correlation

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Example: Two Asset Portfolio

$$\text{Portfolio Risk} = \sqrt{\sigma_1^2 w_1^2 + \sigma_2^2 w_2^2 + 2 w_1 w_2 \text{Cor}_{(1,2)} \sigma_1 \sigma_2}$$

$$= \sqrt{0.16^2 \times 0.80^2 + 0.33^2 \times 0.20^2 + 2 \times 0.8 \times 0.2 \times 0.01 \times 0.16 \times 0.33}$$

$$= \sqrt{0.01638 + 0.00436 + 0.00169}$$

$$= 14.98\%$$

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Example: Two Asset Portfolio

	EXPECTED RETURN	RISK (Standard Deviation)
Asset A	10%	16%
Asset B	18%	33%
Portfolio	11.6%	14.98%

The Combination of the Two Assets Results in a Superior Risk-Return Trade-off

This is the Potential Power of Diversification

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Application: Home Depot and Microsoft Common Stock

	A	B	C	D	E	F	G
1		HD	MSFT	HD var.	MSFT var.	Product	
2	01/01/2019						
3	01/02/2019	6.82	2.82	4.5	(1.5)	(6.8)	=D3*E3
4	01/03/2019	0.88	7.72	(1.4)	3.4	(4.8)	=D4*E4
5	01/04/2019	4.38	5.28	2.1	1.0	2.0	=D5*E5
6	01/05/2019	6.15	10.73	3.9	6.4	24.8	=D6*E6
7	01/06/2019	(6.80)	(4.95)	(9.1)	(9.3)	84.2	=D7*E7
8	Mean	2.3	4.3	=AVERAGE(C3:C7)			
9	Sum of product					99.4	=SUM(F3:F7)
10	Number of observations -1					4.0	=COUNT(F3:F7)-1
11	Covariance					24.9	=F9/F10
12	**Std dev.**	**5.6**	**6.0**	=STDEV.S(C3:C7)			
13	Correlation					0.75	=F11/(B12*C12)
14	Weight	50.0%	50.0%				
15	Weighted deviation	7.8	8.9	=C14^2*C12^2			
16	Sum of the weighted deviation			16.6	=C15+B15		
17	Correlation factor			12.4	=2*F13*B14*C14*B12*C12		
18	Variance			29.1	=D16+D17		
19	**Portfolio standard deviation**			**5.4**	=D18^0.5		

	A	B	C
21	**Portfolio**		
22	Risk free rate	0.574	
23	Market risk premium	6.500	
24	HD levered beta (3 yr adj.)	1.050	
25	MSFT levered beta (3 yr adj.)	1.120	
26	**HD expected return**	**7.40**	=B22+B23*B24
27	**MSFT expected return**	**7.85**	=B22+B23*B25
28	**Weighted average return of portfolio**	**7.63**	=B14*B26+C14*B27

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Diversification and Systematic Risk

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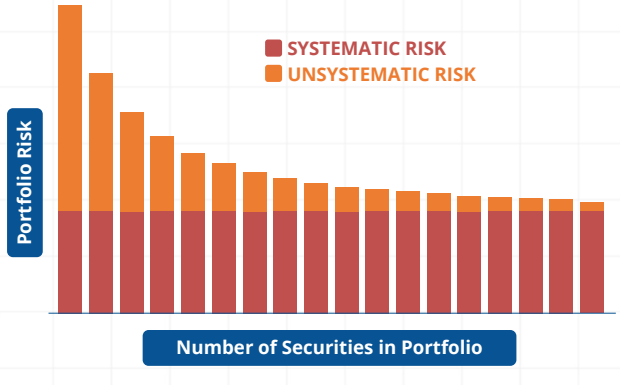

Source: CFA Institute

Asset Pricing Models **(CAPM, APT)** Do Not Include Unsystematic Risk

Unsystematic Risk **Can Be Avoided** Through Diversification

Since Investors Can Eliminate Unsystematic Risk They Are **Not Compensated** (With Higher Returns) For Being Exposed to it

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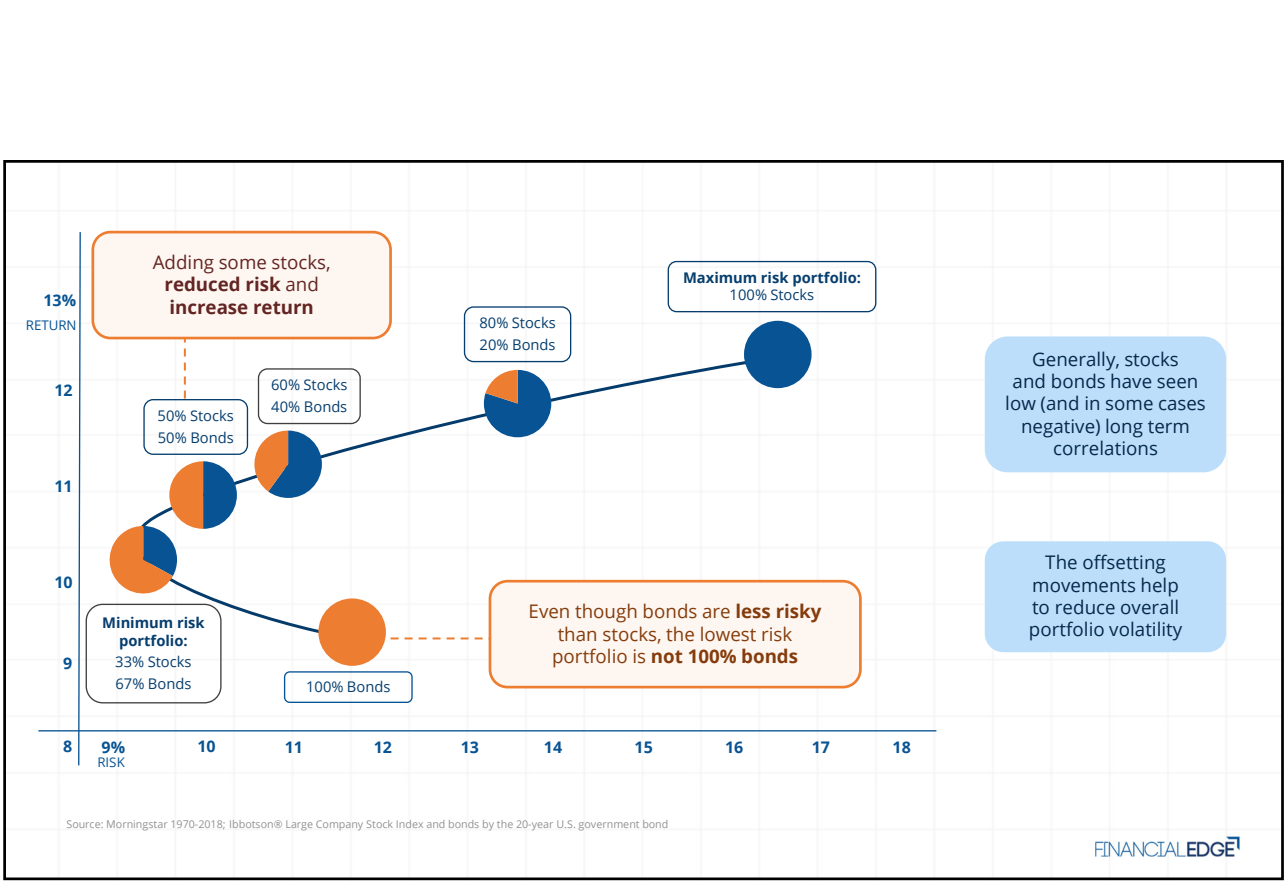
Asset Class Diversification



Source: Morningstar 1970-2018; Ibbotson® Large Company Stock Index and bonds by the 20-year U.S. government bond

	US Large Cap Stocks	US Mid Cap Stocks	US Small Cap Stocks	US Short Term Bonds	US Total Bond Market	US Long Term Bonds	Non US Stocks	Emerging Market Stocks	US Real Estate	Commodities
US Large Cap Stocks	-									
US Mid Cap Stocks	0.96	-								
US Small Cap Stocks	0.94	0.98	-							
US Short Term Bonds	-0.39	-0.43	-0.42	-						
US Total Bond Market	0.04	0.07	0.02	0.53	-					
US Long Term Bonds	-0.34	-0.34	-0.37	0.55	0.79	-				
Non US Stocks	0.89	0.88	0.84	-0.3	0.15	-0.27	-			
Emerging Market Stocks	0.79	0.8	0.76	-0.27	0.14	-0.27	0.94	-		
US Real Estate	0.73	0.77	0.78	-0.2	0.32	-0.02	0.7	0.62	-	
Commodities	0.54	0.55	0.53	-0.22	-0.04	-0.38	0.64	0.65	0.34	-

Problems With Correlation

Correlations Tend Not to Be Constant Over Time

Correlations Often Increase During Crisis, When The Benefits of Diversification Are Most Needed

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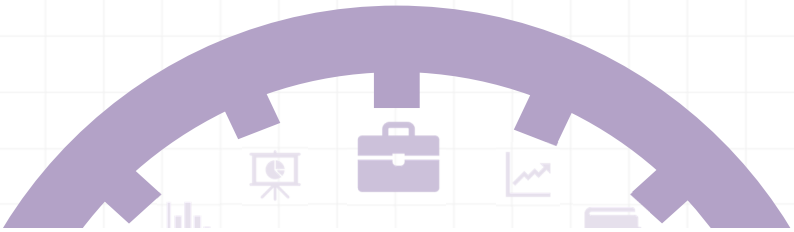

Geographical Diversification

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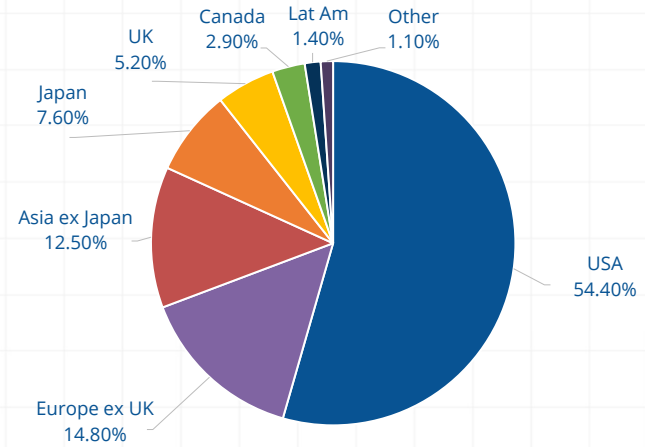
GLOBAL EQUITY MARKETS



Source: Morningstar - Market Capitalizations as of 12/2018

There are significant investment opportunities outside of any investor's home market

International holdings provide Differing exposure and sensitivity To economic and market forces

However, many studies have shown that investors on average have displayed a "home country bias"

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2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Annualised
Emerging debt 8.5%	REITs 23.7%	U.S. equities 32.6%	REITs 22.8%	Japan equities 9.9%	High yield 14.3%	EM equities 37.8%	Cash 1.9%	U.S. equities 31.6%	DM gov. debt 6.7%	U.S. equities 14%
DM gov. debt 6.3%	Europe equities 19.9%	Japan equities 27.3%	U.S. equities 13.4%	U.S. equities 1.3%	Infrastructure 12.4%	Europe equities 26.2%	DM gov. debt -0.4%	Infrastructure 27%	IG credit 6.1%	REITs 7.5%
IG credit 4%	High yield 19.6%	Europe equities 26%	Infrastructure 13%	Emerging debt 1.2%	U.S. equities 11.6%	Japan equities 24.4%	IG credit -3.5%	Europe equities 24.6%	U.S. equities 3.6%	High yield 6.4%
High yield 3.1%	EM equities 18.6%	Infrastructure 15%	Emerging debt 5.5%	REITs 0.6%	EM equities 11.6%	U.S. equities 21.9%	High yield -4.1%	REITs 24.5%	Emerging debt 1.8%	Infrastructure 6.3%
U.S. equities 2%	Emerging debt 18.5%	High yield 7.3%	IG credit 2.5%	Cash 0.1%	Emerging debt 10.2%	Infrastructure 20.1%	U.S. equities -4.5%	Japan equities 20.1%	Cash 0.7%	Japan equities 5.8%
REITs 1.7%	U.S. equities 16.1%	REITs 2.8%	Cash 0.1%	Europe equities -2.3%	Commodities 9.7%	High yield 10.4%	Emerging debt -4.6%	EM equities 18.9%	High yield -0.3%	Emerging debt 5.8%
Cash 0.1%	IG credit 12.4%	IG credit 1.8%	High yield 0%	High yield -2.7%	REITs 6.9%	Emerging debt 9.3%	REITs -4.8%	Emerging debt 14.4%	EM equities -1.5%	Europe equities 5.5%
Infrastructure -0.4%	Infrastructure 11.9%	Cash 0.1%	DM gov. debt -0.8%	DM gov. debt -3.3%	IG credit 6%	IG credit 9.3%	Infrastructure -9.5%	High yield 12.6%	Japan equities -8.4%	IG credit 4.8%
Commodities -8.2%	Japan equities 8.4%	EM equities -2.3%	EM equities -1.8%	IG credit -3.8%	Japan equities 2.7%	REITs 8.6%	Commodities -10.7%	IG credit 11.8%	Europe equities -9%	EM equities 3.7%
Europe equities -10.5%	DM gov. debt 1.8%	DM gov. debt -4.3%	Japan equities -3.7%	Infrastructure -11.5%	DM gov. debt 1.7%	DM gov. debt 7.3%	Japan equities -12.6%	Commodities 11.8%	Infrastructure -16.9%	DM gov. debt 2.3%
Japan equities -14.2%	Cash 0.1%	Commodities -5%	Europe equities -5.7%	EM equities -14.6%	Cash 0.4%	Commodities 1.7%	EM equities -14.2%	DM gov. debt 5.6%	REITs -17.5%	Cash 0.7%
EM equities -18.2%	Commodities -3.3%	Emerging debt -6.6%	Commodities -17.9%	Commodities -23.4%	Europe equities 0.2%	Cash 0.8%	Europe equities -14.3%	Cash 2.3%	Commodities -22.4%	Commodities -5.7%

Source: Blackrock as of August 2020

Little predictability in regional performance From year to year

Us stocks have **outperformed Non-us stocks** in the Current decade

But during previous decade, us stocks **significantly underperformed non-us stocks**

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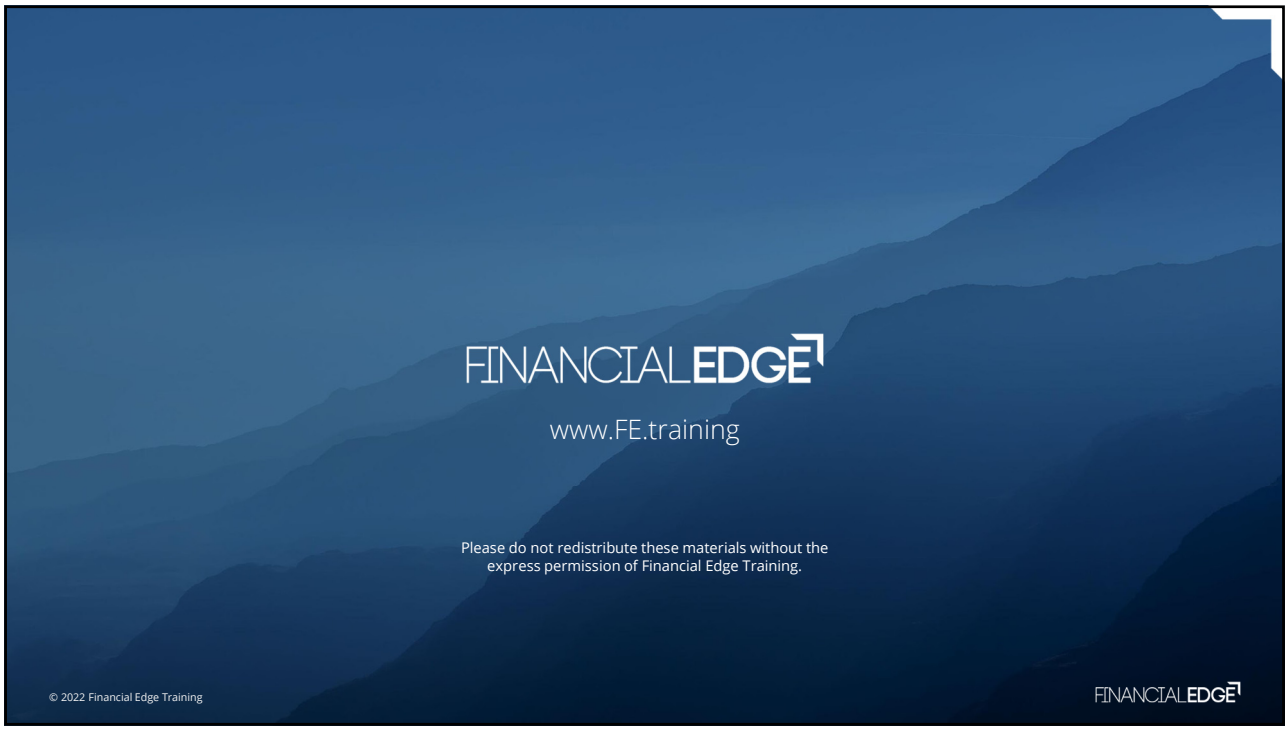
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