

Portfolio Allocation: The Mechanics

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The investor's problem

- Investors are trying to maximize their expected utility.
- Investors face a difficult problem:
 - - Which stocks should they invest in?
 - - How much should they invest in each stock?
- Harry Markowitz was the first person to solve the investor's problem.
 - - H Markowitz, 1952, "Portfolio Selection", Journal of Finance.

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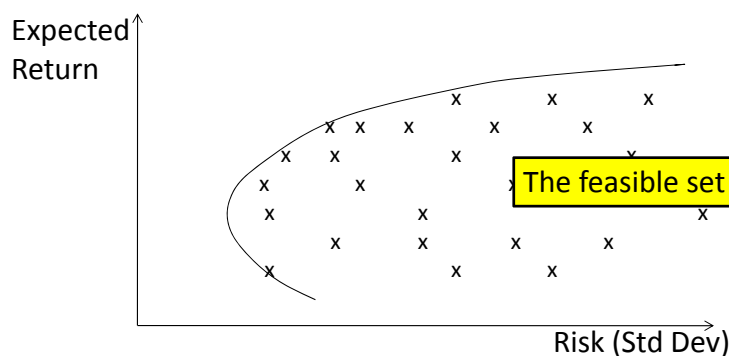
Solving the investor's problem

- Markowitz made several assumptions:
 - - Investors are risk averse.
 - Investors like expected returns.
 - Investors dislike risk as measured by variance.
 - - All investors have the same estimates of expected returns, variances, and correlations.
 - Homogeneous Expectations.
 - - Perfect Markets
 - Investors can borrow and lend as much as they want at the riskless interest rate.
 - No transaction costs.
 - Investors can buy or sell as much as they want, but individual trades do not affect prices.

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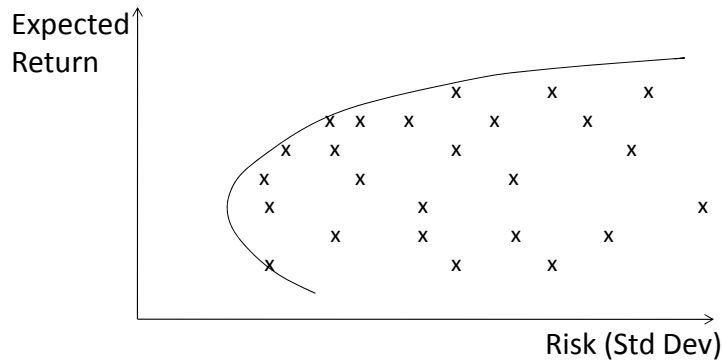
Risk and Expected Return

- There are 1000s of risky investment opportunities.
- Every possible combination of assets can be plotted in risk-return space.
- -The collection of these combinations is called the feasible set.



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Where is the lowest risk portfolio?



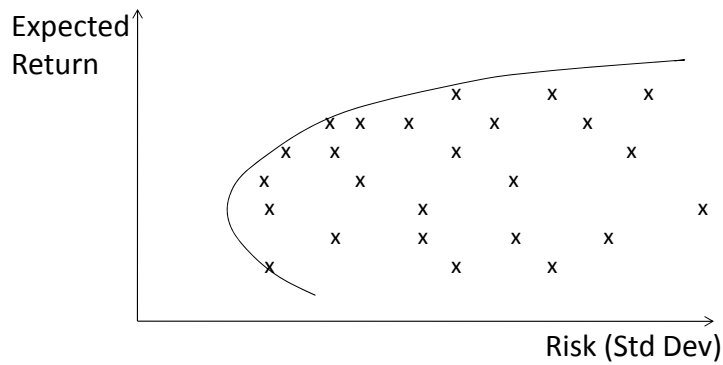
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Efficient portfolios

- An efficient portfolio has the maximum expected return for any given risk level.
- Alternatively:
- An efficient portfolio has the lowest risk for any given level of expected return.
- The combination of all efficient portfolios is called the efficient frontier.

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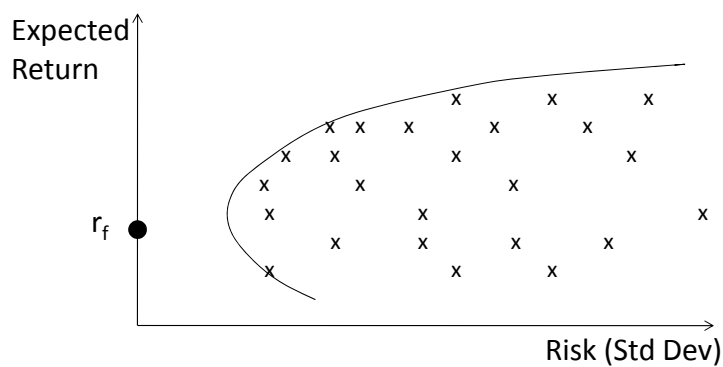
Where is the efficient frontier?



What type of portfolio would all risk averse investors choose to invest in?

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Adding a risk free asset with return r_f .

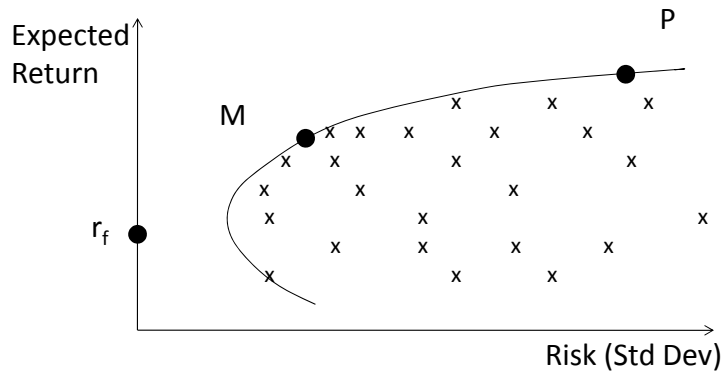


You can invest in any combination of risky assets and the riskless asset.

Which portfolio of risky assets would you invest in?

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Adding a risk free asset with return r_f .

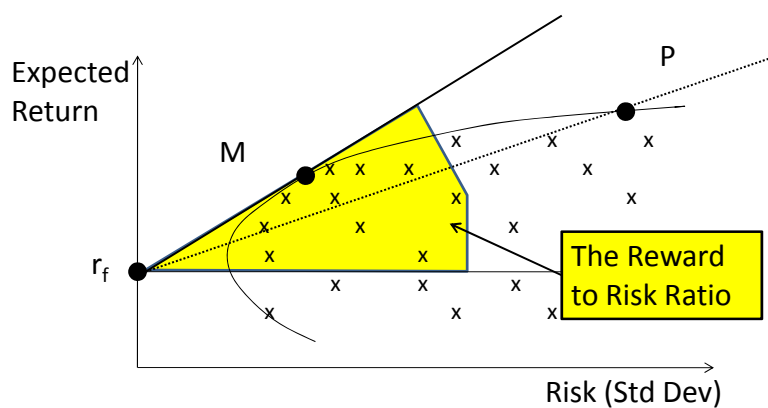


You can invest in any combination of risky assets and the riskless asset.

Which portfolio of risky assets would you invest in?

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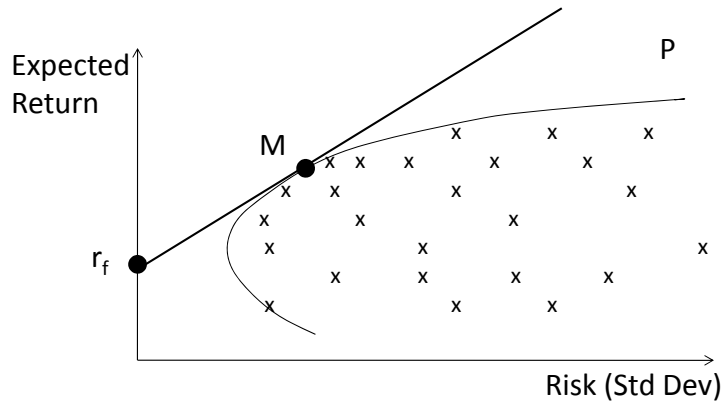
Adding a risk free asset with return r_f .



The OPTIMAL portfolio of risky assets, M, in combination with the riskless asset maximizes the reward to risk ratio.

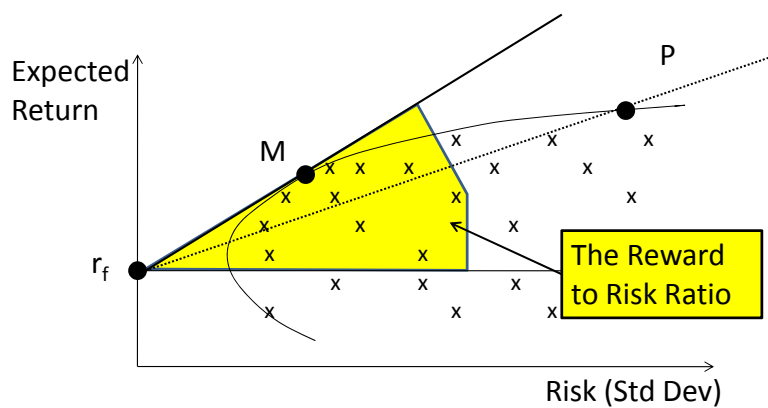
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How would you invest?



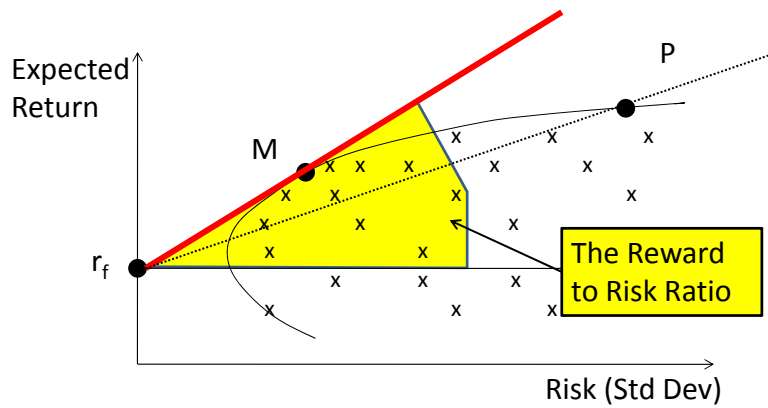
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How would you invest?



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How would you invest?



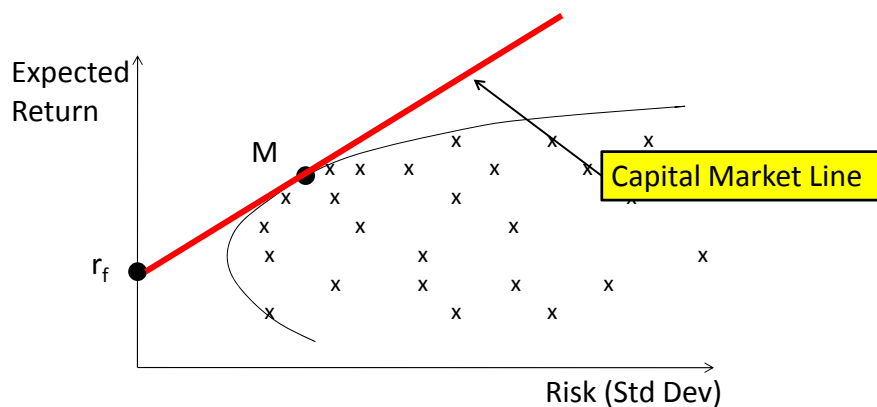
ALL investors will choose some combination of the OPTIMAL portfolio and the riskless asset.

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Two Fund Separation

Choice of M is independent of investor preferences.

- ALL risk averse investors will find that M is the OPTIMAL portfolio.



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All investors hold some combination of the riskless asset and the optimal portfolio, M.

There is a linear relation between expected portfolio returns and risk (std dev) when there is a risk free asset in the economy.

Equilibrium: Risk and Return

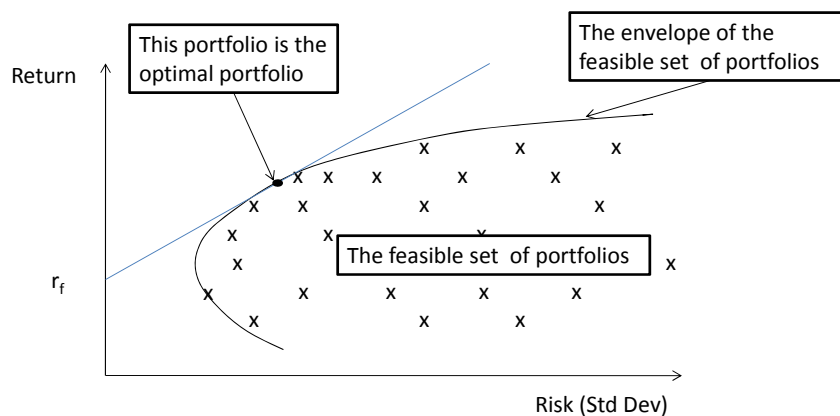
The linear relation is given by the Capital Market Line.

NB: There is not a linear relation between expected returns and risk if there is no risk free asset. The efficient frontier is not linear.

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Finding the Optimal Portfolio

- The optimal portfolio lies on the tangency of the line connecting the point r_f on the vertical axis to the efficient frontier.



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Utility functions and the Optimal Portfolio

- An investor's expected utility is a function of the expected returns on an investment and the risk of the investment.

$$E[U(x)] = E(r_x) - \lambda \sigma_x^2$$

- If an investor wants to find the optimal portfolio they must maximize their expected utility:

$$Max: E[U(P)] = E(r_p - r_f) - \lambda \sigma_{r_p}^2$$

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What is the Choice Variable?

- The investor is trying to find how much to invest in each stock to maximize their utility.

$$Max: U(P) = E(r_p - r_f) - \lambda \sigma_{r_p}^2$$

→

- There is 1 constraint on this problem. The weights must add up to 1: $w^T \mathbf{1} = 1$.
- - There is a trick to get around this constraint.
We will ignore the constraint for the time being.

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Reviewing the Notation

- Assume there are M risky assets each of which has an expected return, denoted μ_m .

$$\mu = \begin{bmatrix} \mu_1 \\ \vdots \\ \mu_M \end{bmatrix}$$

- Let S be the $M \times M$ variance-covariance matrix.

$$S = \begin{bmatrix} \sigma_{11} & \cdots & \sigma_{1M} \\ \vdots & & \vdots \\ \sigma_{M1} & \cdots & \sigma_{MM} \end{bmatrix}$$

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Reviewing the Notation

- To construct a portfolio we need to have a column vector of portfolio weights, w .

$$w = \begin{bmatrix} w_1 \\ \vdots \\ w_M \end{bmatrix} \text{ where } \sum_{i=1}^M w_i = 1 \rightarrow w^T \mathbf{1} = 1$$

- The portfolio's expected return and variance are given by:

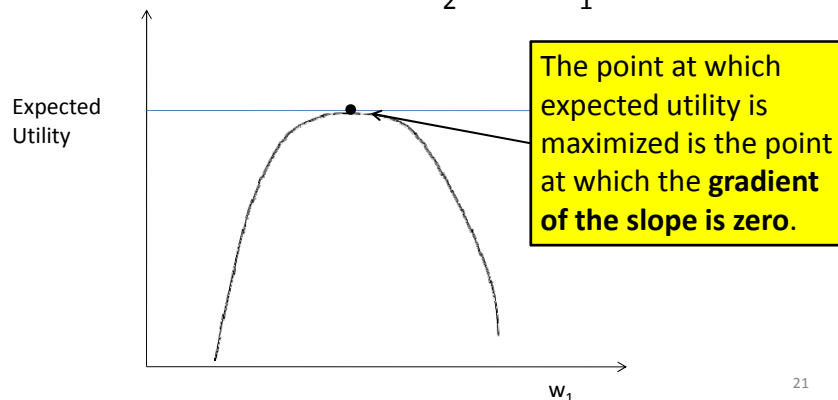
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The Two Asset Case

- Our aim is to find the values for w_1 and w_2 which maximize expected utility:

$$\text{Max}_w : w^T (\mu - r_f) - \lambda w^T S w$$

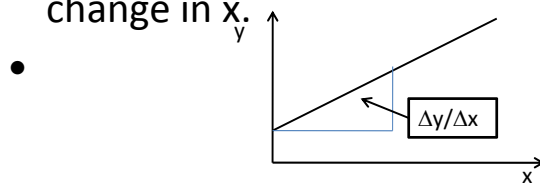
- NB: In the two asset case $w_2 = 1 - w_1$.



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Optimization and Differentiation

- The slope, or gradient, of a line is calculated as the change in y divided by the corresponding change in x .



- We can calculate the slope of a curve using differentiation.

– - The basic rule of differentiation:

$$\text{If } y = x^n \text{ then } \frac{dy}{dx} = nx^{n-1}$$

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Differentiation and the Optimal Portfolio

- Aim:
 - - Maximize expected utility by changing the amount invested in different assets.
- How can we use differentiation to find the optimal portfolio?
- The investor's expected utility will be maximized when the gradient of the slope on the utility function is equal to zero.
 - - Use differentiation to calculate the gradient of the slope.

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The Maths Part

- To find the optimal portfolio we must maximize expected utility with respect to portfolio weights, w :

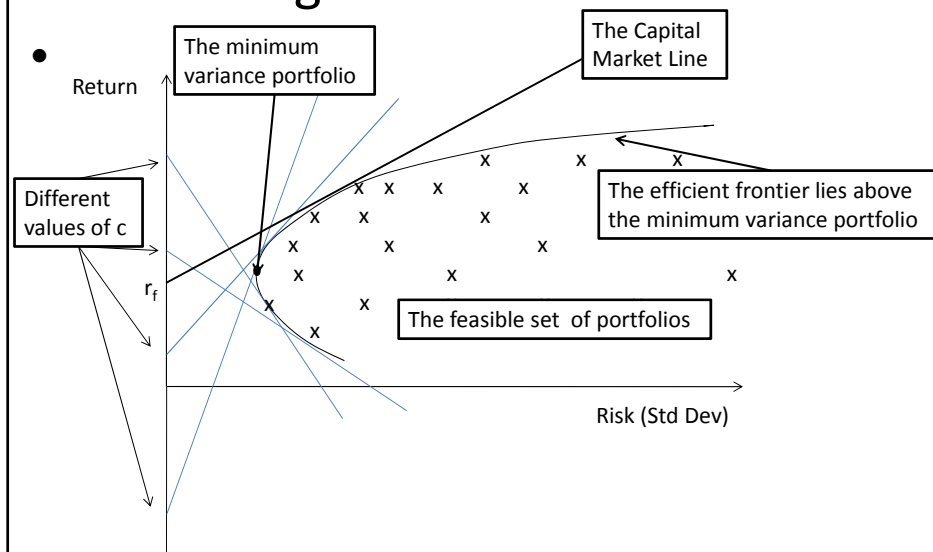
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Finding the Efficient Frontier

- We have found the optimal portfolio. This is a portfolio which lies on the efficient frontier.
- We can also calculate any portfolio on the efficient frontier, or more generally, on the envelope of the feasible set using a similar approach.
- To find the envelope of the feasible set all we need to do is to replace r_f with different values, c , in the maximization problem.
- The efficient frontier will consist of all points on the envelope above the minimum variance portfolio.

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Finding the Efficient Frontier

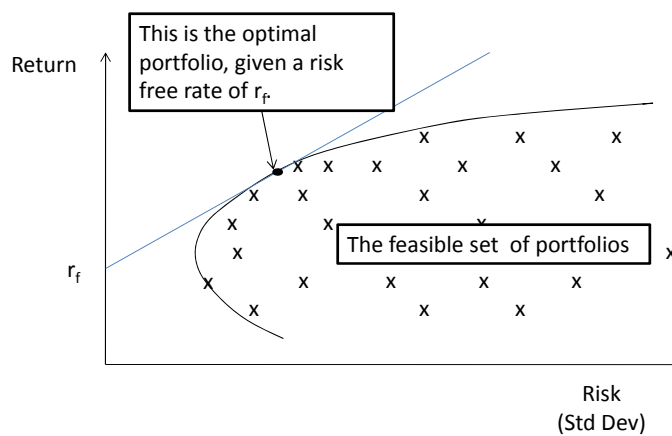


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Portfolio Allocation and Excel

1

The Optimal Portfolio



2

Finding the Optimal Portfolio: Theory

- To find the optimal portfolio we must maximize expected utility:

$$\text{Max}_w : E(r_p - r_f) - \lambda \sigma_{r_p}^2$$

$$\rightarrow \text{Max}_w : w^T (\mu - r_f) - \lambda w^T S w$$

Differentiate with respect to w and set equal to zero:

$$\rightarrow (\mu - r_f) = S z \text{ where } z = 2\lambda w$$

$$\rightarrow z = S^{-1} (\mu - r_f)$$

$$\rightarrow w = \frac{z}{1^T z}$$

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Portfolio Allocation Inputs

- Portfolio theory focuses on expected returns and the expected variance-covariance matrix.
 - We do not observe expected returns.
 - We do not observe the expected variance-covariance matrix.
- Practitioners must make estimates for all of these inputs.

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Portfolio Allocation Inputs

- Estimating Expected Returns

- Use historical data:

$$r_{i,t} = \mu_i + \varepsilon_{i,t} \text{ where } \varepsilon_{i,t} \sim N(0, \sigma_i^2)$$

$$\rightarrow \frac{1}{N} \sum_{t=1}^N r_{i,t} = \frac{1}{N} \sum_{t=1}^N \mu_i + \frac{1}{N} \sum_{t=1}^N \varepsilon_{i,t} \approx \mu_i$$

- Use CAPM:

$$E(r_i) = r_f + \beta_i (E(r_m) - r_f)$$

- Estimating the Variance-Covariance Matrix

- Use historical data.

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Setting up the inputs in Excel

Portfolio Allocation and implied returns - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Add-Ins Get Started

Insert Function AutoSum Recently Financial Logical Text Data & Lookup & Trig Math More Functions Name Manager Use in Formula Create from Selection Defined Names Trace Precedents Trace Dependents Error Checking Remove Arrows Evaluate Formula Formula Auditing Calculate Now Calculation Options Calculate Sheet Calculation

Function Library

Formulas

INDEX(LINEST(I4:I69,mkt_ret,,1,1,1))

	A	E	F	G	H	I	J	K	L	M	N	O	P
1								Returns					
2	Month	MRK	XOM	S&P 500		INTC	AEP	AMZN	MRK	XOM	S&P 500		INTC
60	58	44.33	70.51	1377.94		0.037	0.139	0.186	0.084	0.064	0.032		0.03636
61	59	43.44	78.16	1400									0.00743
62	60	42.91	75.98	1418									-0.05448
63	61	44.04	73.47	1439									0.03427
64	62	43.45	71.37	1406.82		-0.047	0.040	0.039	-0.013	-0.029	-0.022		-0.04791
65	63	43.84	75.13	1420.86		-0.037	0.086	0.017	0.009	0.053	0.010		-0.0378
66	64	51.06	79.04	1482.37		0.124	0.030	0.541	0.165	0.052	0.043		0.12336
67	65	52.06	83.17	1530.62		0.037	-0.044	0.127	0.020	0.052	0.033		0.03828
68	66	49.80	83.88	1503.35		0.070	-0.054	-0.011	-0.043	0.009	-0.018		0.06968
69	67	50.12	85.59	1473.91		-0.008	-0.041	0.228	0.006	0.020	-0.020		-0.00906
70													
71				Av Ret		0.001	0.007	0.037	0.004	0.015	0.005		0.000
72				Variance		0.011	0.004	0.020	0.006	0.003	0.001		
73				Std Dev		0.107	0.065	0.142	0.078	0.055	0.035		
74				Beta		2.032	0.984	1.664	0.849	0.780	1.000		
75													
76				Correlations									
						INTC	AEP	AMZN	MRK	XOM			
									0.195	0.121			
									0.22				
									0.13				
									1.00				

Expected returns based on historical data.

To calculate expected returns using the CAPM we need to estimate β s.

$=\text{INDEX}(\text{LINEST}(I4:I69,\text{mkt_ret},,1,1,1))$

Named Range: betas

Average: 1.258 Count: 5 Sum: 6.290 141%

3:50 PM

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Setting up the inputs in Excel

Portfolio Allocation Inputs

	Annual	Monthly
Risk Free Rate	0.05	0.00417
Market Risk Premium	0.08	0.00667

Portfolio Allocation Calculations

	μ_{hist}	μ_{CAPM}
INTC	0.0007	0.0177
AEP	0.0068	0.0106
AMZN	0.0368	0.0153
MRK	0.0044	0.0098
XOM	0.0153	0.0094

Calculate CAPM Expected Returns:

- 1) Select 5 x 1 column vector
- 2) $= rf + \text{TRANPOSE}(\text{betas}) * rp$
- 3) Press Ctrl + Shift + Enter

Setting up the inputs in Excel

Portfolio Allocation Inputs

	Annual	Monthly
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Portfolio Allocation Calculations

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AMZN	0.0368	0.0153
MRK	0.0044	0.0098
XOM	0.0153	0.0094

Expected Excess Returns (CAPM):

- 1) Select 5 x 1 column vector
- 2) $= \mu_{capm} - rf$
- 3) Press Ctrl + Shift + Enter

Finding the Optimal Portfolio: Step 1

- We have to solve the matrix algebra problem to find z: $z = S^{-1}(\mu - r_f)$
- To calculate the inverse of a square matrix in Excel we have to use the matrix function:
- =MINVERSE()

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Finding the Optimal Portfolio

Calculate Z based on CAPM Expected Excess Returns:

- 1) Select cells E17:E21
- 2) =MMULT(MINVERSE(S),ex_mu_capm)
- 3) Press: Ctrl + Shift + Enter

Named Range: ex_mu_hist

Named Range: S

Named Range: ex_mu_capm

	INTC	AEP	AMZN	MRK	XOM
INTC	0.0117	0.0007	0.0073	0.0016	0.0007
AEP	0.0007	0.0043	0.0012	0.0011	0.0011
AMZN	0.0073	0.0012	0.0202	0.0015	0.0000
MRK	0.0016	0.0011	0.0015	0.0061	0.0011
XOM	0.0007	0.0011	0.0000	0.0011	0.0030

	INTC	AEP	AMZN	MRK	XOM
INTC	-0.0035	0.01354	-2.05493	0.94891	
AEP	0.0026	0.00643	-0.72153	0.99562	
AMZN	0.03267	0.11109	2.47172	0.12823	
MRK	0.00021	0.0076	-0.75199	0.26896	
XOM	0.01113	0.0057	4.74604	1.06336	
Sums			3.6893	3.39507	

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Finding the Optimal Portfolio: Step 2

- We have to add up all the elements of Z, and then divide each element of Z by the sum to calculate the portfolio weights:

$$w = \frac{Z}{1^T Z}$$

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Finding the Optimal Portfolio: Step 2

The screenshot shows an Excel spreadsheet titled "Portfolio Allocation and Evaluation - Microsoft Excel". The spreadsheet is divided into two main sections: "Portfolio Allocation Calculations" and "Portfolio Allocation Outputs".

Portfolio Allocation Calculations:

	Hist	CAPM	Hist	CAPM
INTC	-0.0035	0.01354	-2.05493	0.94891
AEP	0.0026	0.00843	-0.72153	0.99562
AMZN	0.03267	0.01109	2.47172	0.12823
MRK	0.00021	0.00568	-0.75199	0.26896
XOM	0.01113	0.0052	4.74604	1.06336
Sum			3.6893	3.39502

Portfolio Allocation Outputs:

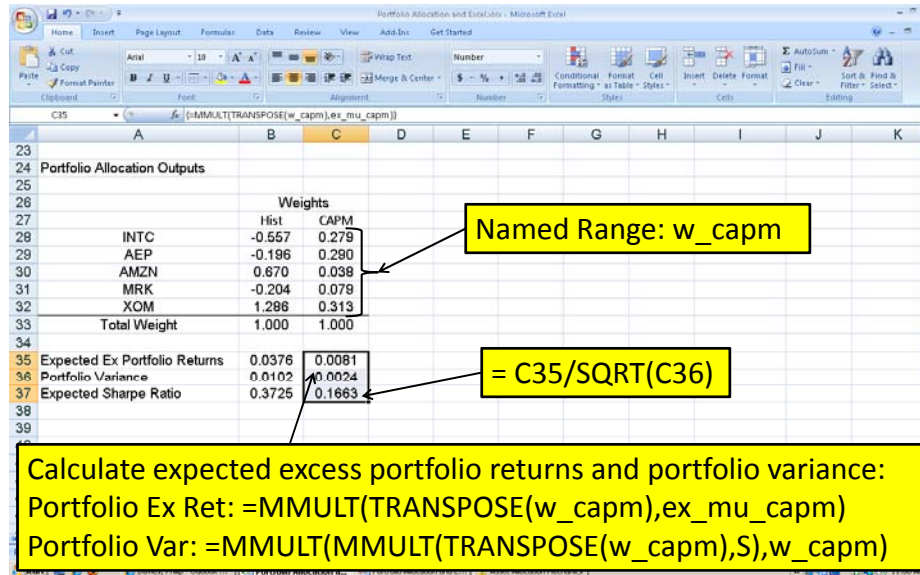
	Hist	CAPM
INTC	-0.557	0.279
AEP	-0.196	0.290
AMZN	0.670	0.038
MRK	-0.204	0.079
XOM	1.286	0.313
Total Weight	1.000	1.000

Annotations:

- Named Range: Z_capm**: Points to the CAPM column in the calculations table.
- Named Cell: sumZ_capm**: Points to the sum of the CAPM column in the calculations table.
- Calculate weights based on CAPM Expected Excess Returns:**
 - 1) Select cells C28:C32
 - 2) =Z_capm/sumZ_capm
 - 3) Press: Ctrl + Shift + Enter
- Check weights sum to 1.**: Points to the Total Weight row in the outputs table.

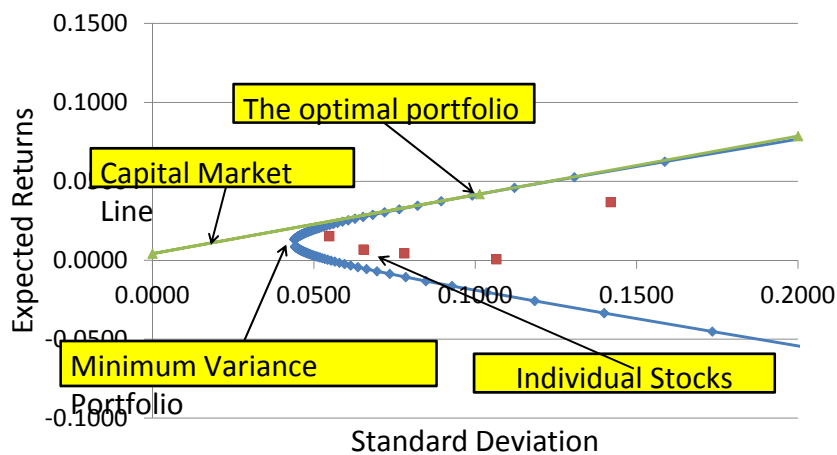
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Finding the Optimal Portfolio: Step 2



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The Efficient Frontier (using historical returns)



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An Optimal Portfolio without Short Sales

- In the analysis so far we have assumed that short sales are allowed. This means that the weight of a stock can be negative in the optimal portfolio.
- While some institutions may be able to short sell stocks without incurring large costs, many investors cannot, or are restricted from short selling.
- How do we find the optimal portfolio when the holdings of all stocks must be greater than or equal to zero?

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Incorporating Short Sales Constraints

- We want to maximize expected utility. The only difference is that we have an additional constraint.
- No stocks can have negative weights in the optimal portfolio.

$$\text{Max}_w: \frac{E(r_p - r_f)}{\sigma_p}$$

Maximize the reward to risk (Sharpe) ratio.

$$\text{Subject to: } \sum_{i=1}^N w_i = 1 \text{ and } w_i \geq 0 \text{ for all } i = 1, \dots, N$$

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Setting up the Problem in Excel

Named Range: ex_mu_hist

Named Range: ex_mu_capm

Named Range: w_hist_ns

Named Range: w_capm_ns

Portfolio Allocation Calculations

	Hist	CAPM	Hist	CAPM
INTC	-0.0035	0.01354	-2.05493	0.94891
AEP	0.0028	0.00643	-0.72153	0.98562
AMZN	0.03287	0.01109	2.47172	0.12823
MRK	0.00021	0.00566	-0.75199	0.26896
XOM	0.01113	0.0052	4.74804	1.06336
Sum			3.6893	3.39507

Portfolio Allocation Outputs

	Unrestricted Weights		No Short Selling Weights	
	Hist	CAPM	Hist	CAPM
INTC	-0.557	0.278	0.2	0.2
AEP	-0.196	0.290	0.2	0.2
AMZN	0.670	0.038	0.2	0.2
MRK	-0.204	0.079	0.2	0.2
XOM	1.286	0.313	0.2	0.2
Total Weight	1.000	1.000	1.000	1.000

Expected Ex Portfolio Returns

	Hist	CAPM	Hist	CAPM
Expected Ex Portfolio Returns	0.0376	0.0081	0.0086	0.0084
Portfolio Variance	0.0102	0.0024	0.0031	0.0031

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Setting up the Problem in Excel

Calculate the expected excess portfolio return, the portfolio variance, and the Sharpe ratio:

Exp Ex Port Ret: =MMULT(TRANSPOSE(w_capm_ns),ex_mu_capm)

Port Var: =MMULT(MMULT(TRANSPOSE(w_capm_ns),S), w_capm_ns)

Reward to Risk (Sharpe) Ratio: =E35/SQRT(E36)

Portfolio Allocation Outputs

	Unrestricted Weights		No Short Selling Weights	
	Hist	CAPM	Hist	CAPM
INTC	-0.557	0.278	0.200	0.200
AEP	-0.196	0.290	0.200	0.200
AMZN	0.670	0.038	0.200	0.200
MRK	-0.204	0.079	0.200	0.200
XOM	1.286	0.313	0.200	0.200
Total Weight	1.000	1.000	1.000	1.000

Expected Ex Portfolio Returns

	Hist	CAPM	Hist	CAPM
Expected Ex Portfolio Returns	0.0376	0.0081	0.0086	0.0084
Portfolio Variance	0.0102	0.0024	0.0031	0.0031
Reward to Risk Ratio	0.3725	0.1663	0.1551	0.1506

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Loading Solver in Excel

You may have to load the Solver Add-in if you have never used Solver before.

Click on the "Office Button"

Select "Excel Options".

Asset	Weight	Expected Ex Portfolio Returns	Portfolio Variance	Reward to Risk Ratio
INTC	0.00643	-0.72153	0.99562	
AEP	0.01109	2.47172	0.12823	
AMZN	0.00566	-0.75199	0.26896	
MRK	0.0052	4.74604	1.06336	
XOM	3.6893	3.39507		
Total Weight	1.000	1.000	1.000	1.000
Expected Ex Portfolio Returns	0.0376	0.0081	0.0086	0.0084
Portfolio Variance	0.0102	0.0024	0.0031	0.0031
Reward to Risk Ratio	0.3725	0.1663	0.1551	0.1506

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Loading Solver in Excel

Select "Add-Ins".

All active "Add-ins" are listed. If "Solver" is listed you can exit.

Select "Go" if Solver is not listed as an active "Add-in".

Name	Location	Type
Active Application Add-ins		
Analysis ToolPak	C:\Program Files\Microsoft Office\Office12\Library\Analysis\ANALYS32.XLL	Excel Add-in
Analysis ToolPak - VBA	C:\Program Files\Microsoft Office\Office12\Library\Analysis\ANALYS32.VBA	Excel Add-in
Microsoft Office Excel 2007 Get Started Tab	mscore.dll	COM Add-in
SnagIt Add-in	C:\Program Files\SnagIt\SnagIt\SnagItOfficeAddin.dll	COM Add-in
Solver Add-in	C:\Program Files\Microsoft Office\Office12\Library\GOVER\GOVER.XLAM	Excel Add-in
Inactive Application Add-ins		
Conditional Sum Wizard	C:\Program Files\Microsoft Office\Office12\Library\SUMF\XLAM	Excel Add-in
Custom XML Data	C:\Program Files\Microsoft Office\Office12\OFFRD\DLL	Document Inspector
File (Smart Tag List)	C:\Program Files\Microsoft Office\Office12\Smart Tag\MSSTL.DLL	Smart Tag
Person Name (Outlook e-mail recipient)	C:\Program Files\Microsoft Office\Office12\Smart Tag\NAME.DLL	Smart Tag
Document Related Add-ins		
None Document Related Add-ins		
Add-in:	Analysis ToolPak	
Publisher:	Microsoft Corporation	
Location:	C:\Program Files\Microsoft Office\Office12\Library\Analysis\ANALYS32.XLL	
Description:	Provides data analysis tools for statistical and engineering analysis.	
Manage:	Excel Add-ins	Go...

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Loading Solver in Excel

Select "Solver Add-in". Press "OK".

	Hist	CAPM	Hist	CAPM
INTC	-0.0035	0.01354	-2.05493	0.94891
AEP	0.0026	0.00643	-0.72153	0.98562
AMZN	0.03267	0.01109	2.47172	0.12823
MRK	0.00021	0.00566	-0.75199	0.26896
XOM	0.01113	0.0052	4.74604	1.06336
Total Weight	1.000	1.000	1.000	1.000
Expected Ex Portfolio Returns	0.0376	0.0081	0.0086	0.0084
Portfolio Variance	0.0102	0.0024	0.0031	0.0031
Reward to Risk Ratio	0.3725	0.1663	0.1551	0.1506

Using Solver to Find the Optimal Portfolio

To use the solver select the Data tab.

The Target Cell is the Sharpe Ratio. Named cell: "RR_capm_ns"

Solver can change the portfolio weights. Named range: w_capm_ns.

There are 2 constraints that we must add.

- 1) The weights must sum to 1. (sumW_capm = 1)
- 2) All the weights must be greater than or equal to 0. (w_capm_ns >= 0)

	Hist	CAPM	Hist	CAPM
INTC	-0.0035	0.01354	-2.05493	0.94891
AEP	0.0026	0.00643	-0.72153	0.98562
AMZN	0.03267	0.01109	2.47172	0.12823
MRK	0.00021	0.00566	-0.75199	0.26896
XOM	0.01113	0.0052	4.74604	1.06336
Sum	3.6893	3.6507		
Restricted Weights				
CAPM	Hist	CAPM		
0.279	0.200	0.200		
0.290	0.200	0.200		
0.038	0.200	0.200		
0.079	0.200	0.200		
0.313	0.200	0.200		
1.000	1.000	1.000		
0.0081	0.0086	0.0084		
0.0024	0.0031	0.0031		
0.3725	0.1663	0.1551		

The Optimal Portfolio with No Short Sales

Allocation using CAPM Exp Ex Returns is the same as it was in unrestricted model.

Does this make sense? Why?

Portfolio Allocation Outputs		Unrestricted Weights		No Short Selling Weights	
		Hist	CAPM	Hist	CAPM
INTC		-0.557	0.279	0.000	0.279
AEP		-0.196	0.290	0.000	0.290
AMZN		0.670	0.038	0.304	0.038
MRK		-0.204	0.079	0.000	0.079
XOM		1.286	0.313	0.696	0.313
Total Weight		1.000	1.000	1.000	1.000
Expected Ex Portfolio Returns		0.0376	0.0081	0.0177	0.0081
Portfolio Variance		0.0102	0.0024	0.0033	0.0024
Reward to Risk Ratio		0.3725	0.1663	0.3074	0.1663

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Incorporating different constraints

- Many funds have investment “charters” that provide guidelines on what percentage of funds can be allocated to a specific stock or industry.
- Suppose we have the following constraints:
 - - Hold at least 10% in each stock.
 - - Hold no more than 30% in any stock.
- How do we find the optimal portfolio with these extra constraints?

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Incorporating different constraints

The image shows an Excel spreadsheet with a Solver Parameters dialog box open. The Solver is set to maximize the cell 'w_capm_ns' (cell D17) by changing the cell 'w_capm_ns' (cell D17). The constraints are 'w_capm_ns >= 0.1' and 'w_capm_ns <= 0.3'. The Solver is set to use the GRG Nonlinear engine and has the 'Make Unconstrained Variables Non-Negative' checkbox checked. The 'Load/Save' button is also visible.

The spreadsheet contains the following data:

	A	B	C	D	E
17	INTC	-0.0035	0.01354	-2.05493	0.94891
18	AEP	0.0026	0.00643	-0.72153	0.98562
19	AMZN	0.03267	0.01109	2.47172	0.12823
20	MRK	0.00021	0.00566	-0.75199	0.26896
21	XOM	0.01113	0.0052	4.74604	1.06336
22	Sum		3.6893	3.39507	

Portfolio Allocation Outputs

	Unrestricted Weights	No Short Selling Weights	
27	Hist	Hist	
28	CAPM	CAPM	
29	INTC	-0.557	0.279
30	AEP	-0.196	0.290

There are 3 constraints that we must add.

- 1) The weights must sum to 1. (sumW_capm = 1)
- 2) All the weights must be greater than or equal to 10%. (w_capm_ns >= 0.10)
- 3) All the weights must be less than or equal to 30%. (w_capm_ns <= 0.30)

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Incorporating different constraints

The screenshot displays an Excel spreadsheet with the following data:

	A	B	C	D	E
17	INTC	-0.0035	0.01354	-2.05493	0.94891
18	AEP	0.0026	0.00643	-0.72153	0.98562
19	AMZN	0.03267	0.01109	2.47172	0.12823
20	MRK	0.00021	0.00566	-0.75199	0.26896
21	XOM	0.01113	0.0052	4.74604	1.06336
22	Sum			3.6893	3.39507

Portfolio Allocation Outputs

	Unrestricted Weights		No Short Selling Weights		
	Hist	CAPM	Hist	CAPM	
28	INTC	-0.557	0.279	0.100	0.238
29	AEP	-0.196	0.290	0.200	0.262
30	AMZN	0.670	0.038	0.300	0.100
31	MRK	-0.204	0.079	0.100	0.100
32	XOM	1.286	0.313	0.300	0.300
33	Total Weight	1.000	1.000	1.000	1.000

35	Expected Ex Portfolio Returns	0.0376	0.0081	0.0133	0.0081
36	Portfolio Variance	0.0102	0.0024	0.0034	0.0025
37	Reward to Risk Ratio	0.3725	0.1663	0.2275	0.1641

Allocation using CAPM Expected Ex Returns is not the same as it was in unrestricted model.

Does this make sense? Why?

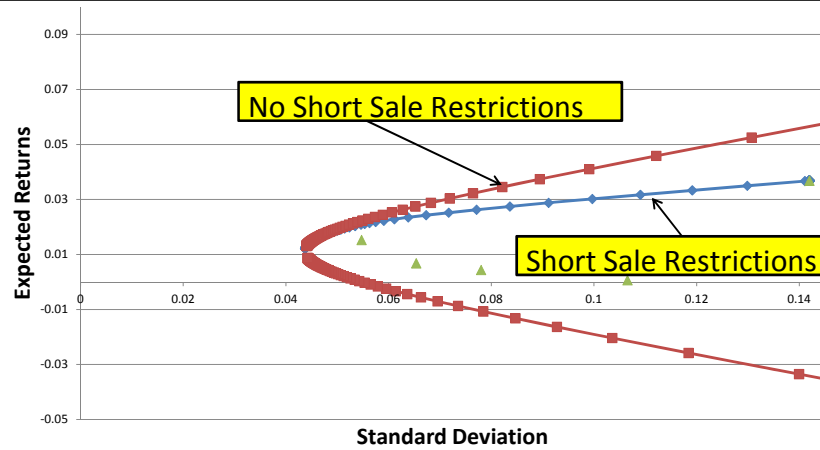
Allocation using CAPM Exp Ex Returns is not the same as it was in unrestricted model.

Does this make sense? Why?

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The Different Efficient Frontiers

Why does the efficient frontier in which short sales are allowed plot above the efficient frontier in which short sales are not allowed?



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