Welcome to the course

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

Kris Boudt

Professor, Free University Brussels & Amsterdam

datacamp

Is investing monkey-business?

[1] Source: Eric Isselee, Getty Images

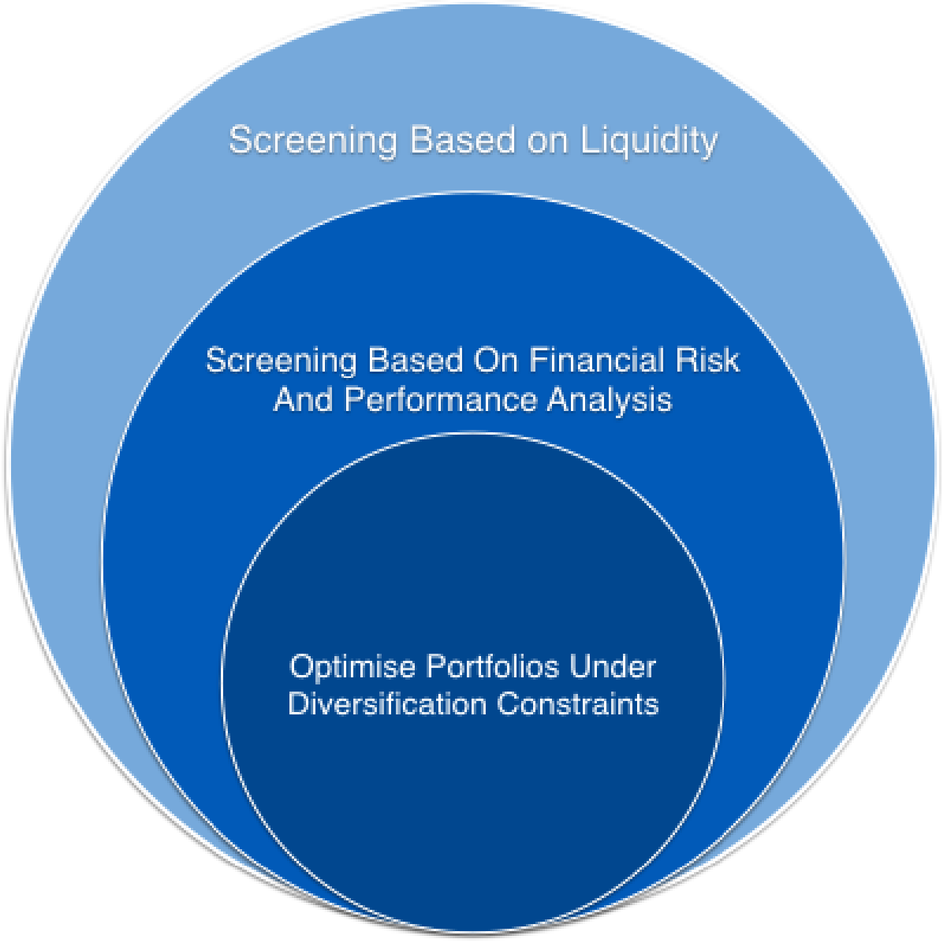
Who am I?

- Professor of Finance

Who am I?

- Advisor to investment companies about risk optimized investment: Winning by losing less.

Diversify to avoid losses



Simple tricks

- To avoid large losses:
  - Carefully select diversified portfolios
  - Use backtesting and online performance monitoring

Simple tricks

- DataCamp

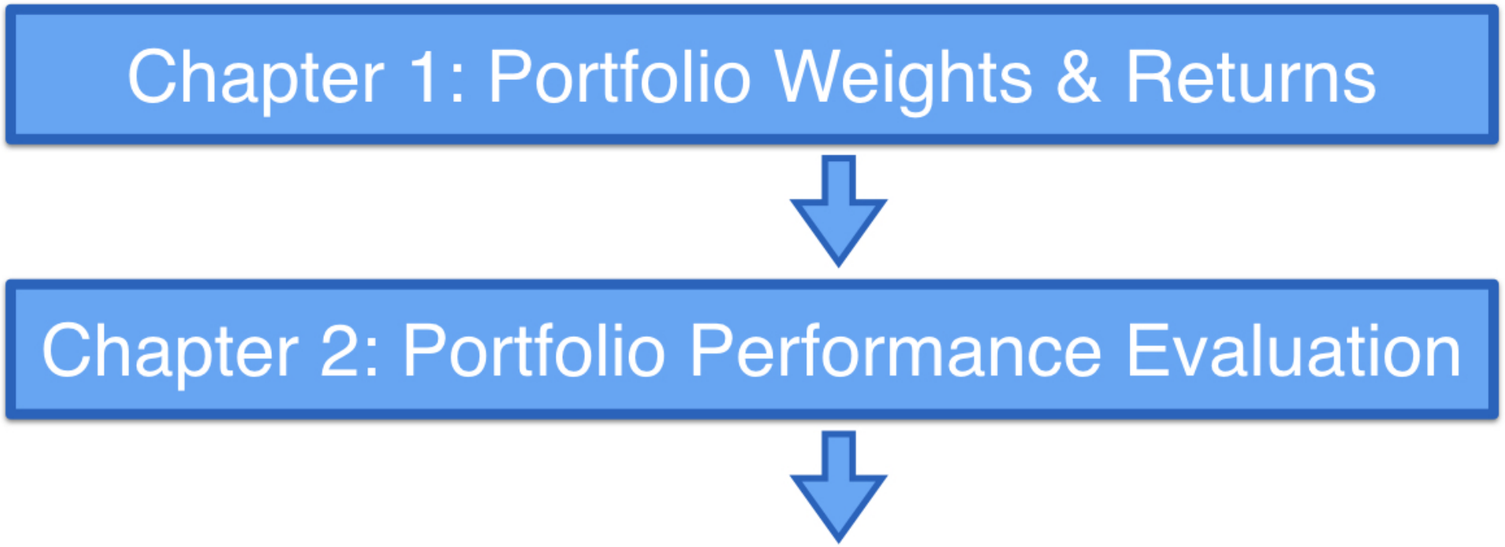
Course overview

Chapter 1: Portfolio Weights & Returns

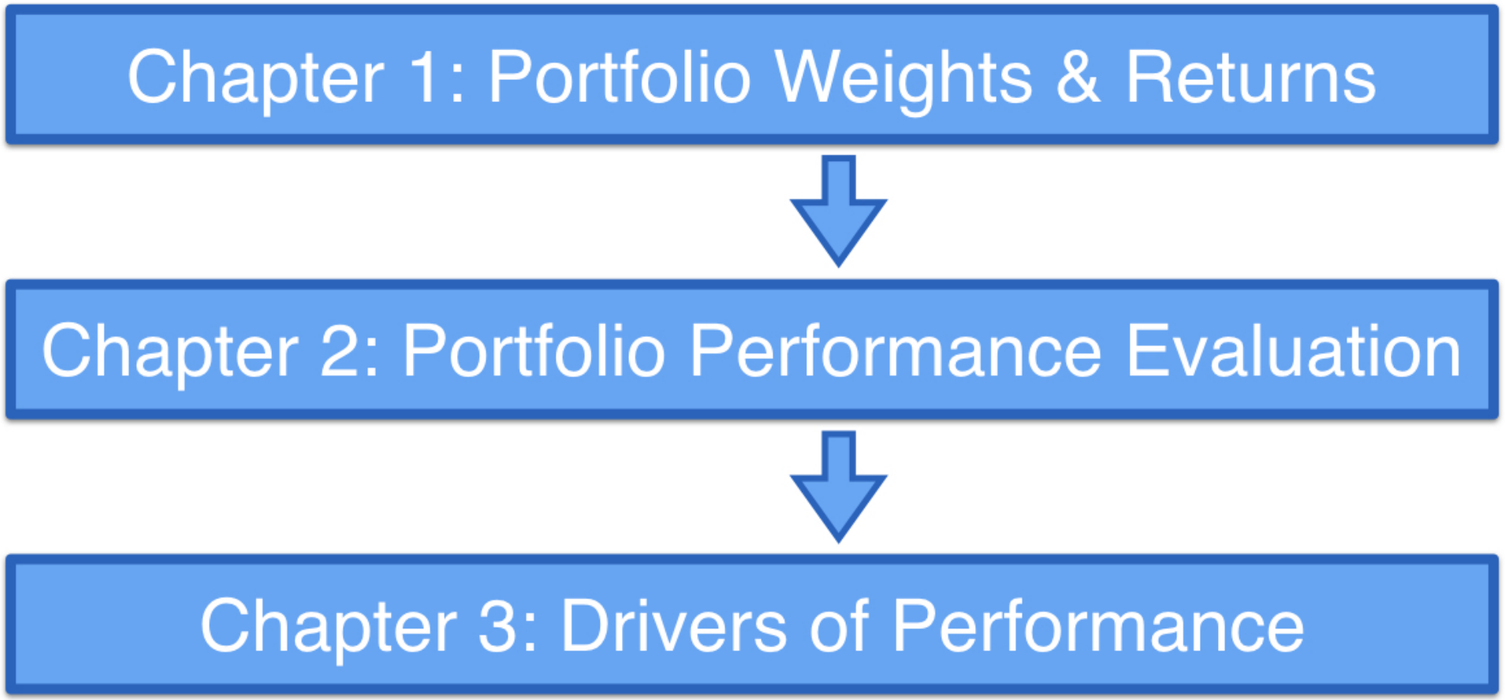
Course overview

Course overview

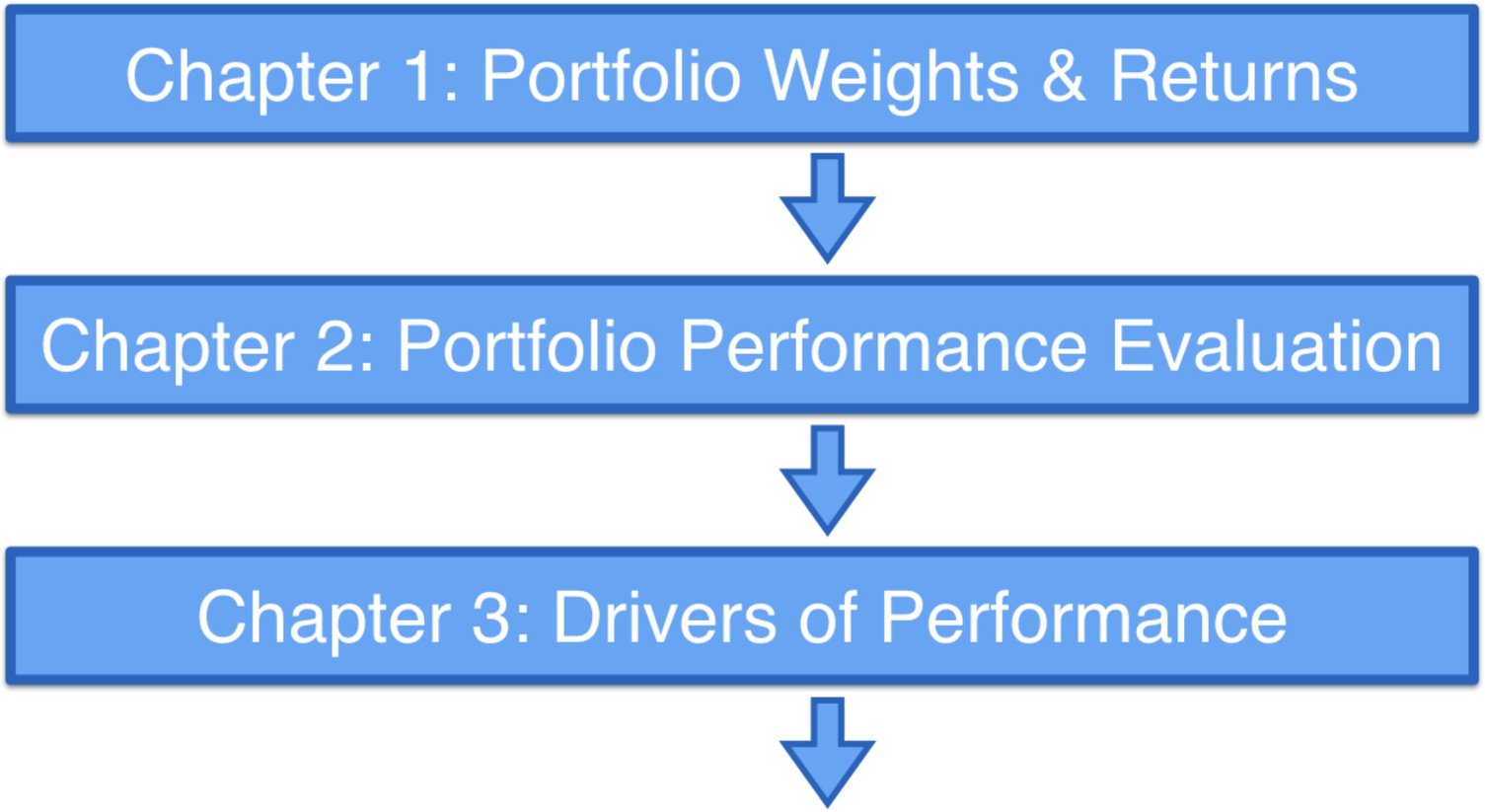
Course overview



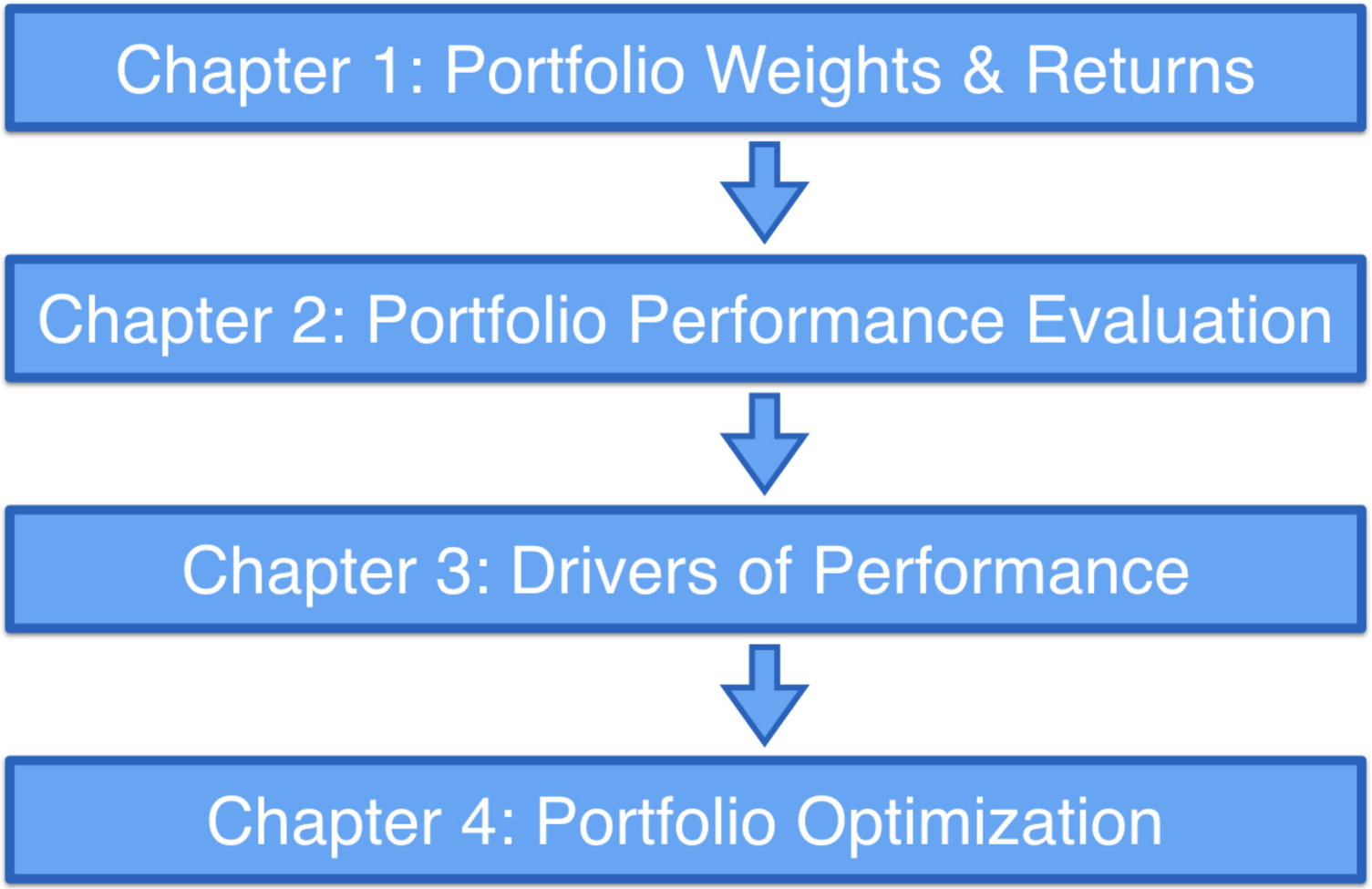
Course overview



Course overview



Course overview



Let's practice!

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

The portfolio weights

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

Kris Boudt

Professor, Free University Brussels & Amsterdam

datacamp

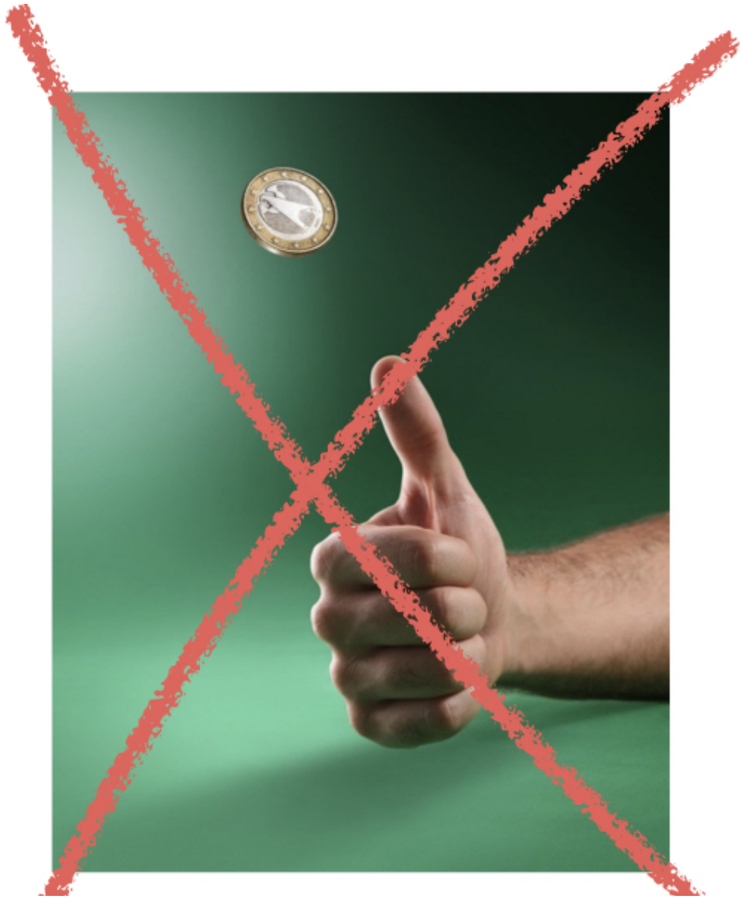
Investment decision choices

There are two similar companies: Do you invest in either of them based on a coin toss?

[1] Source: ICMA Photos, Flickr

Investment decision choices

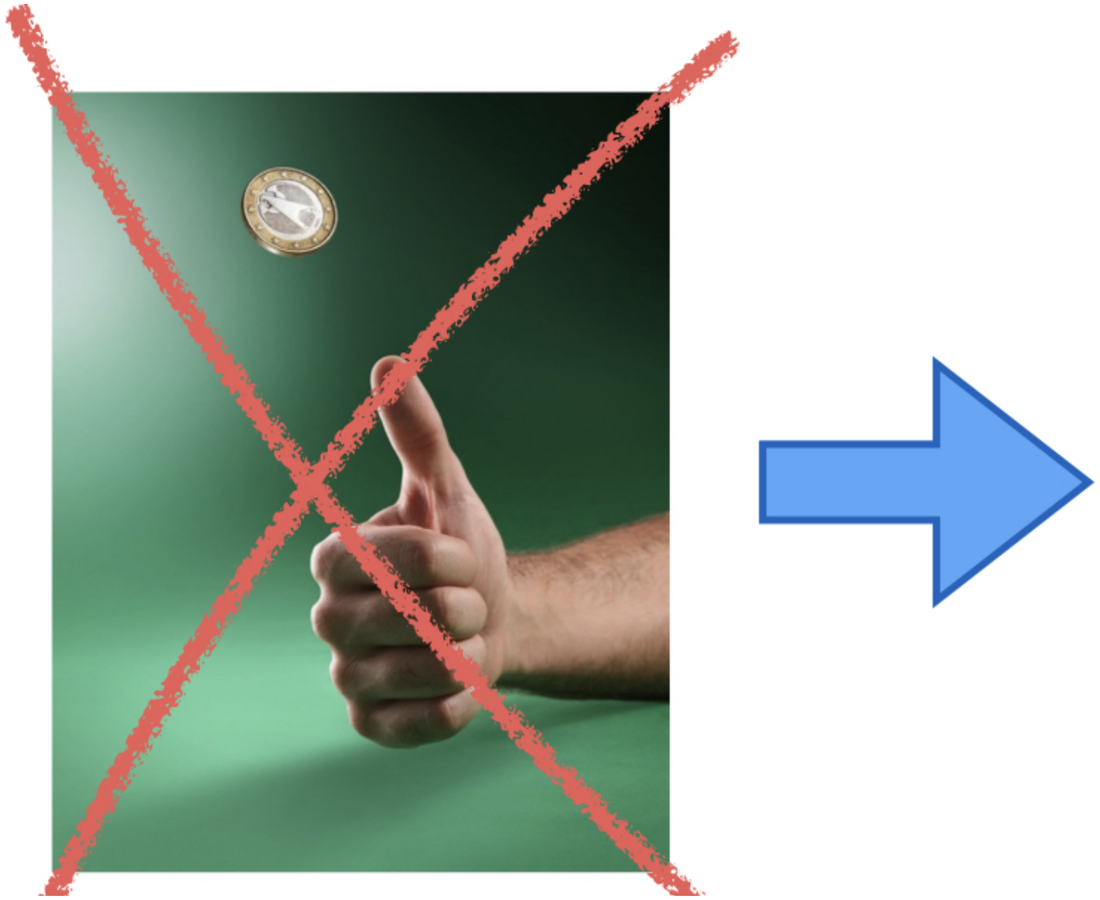
There are two similar companies: Do you invest in either of them based on a coin toss?



[1] Source: ICMA Photos, Flickr

Investment decision choices

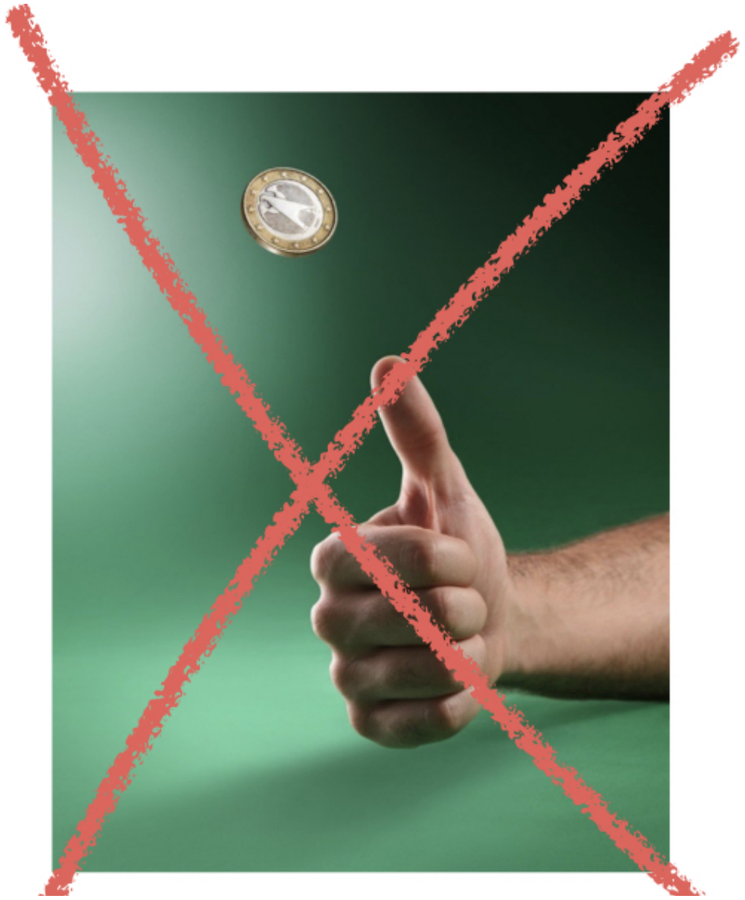
There are two similar companies: Do you invest in either of them based on a coin toss?

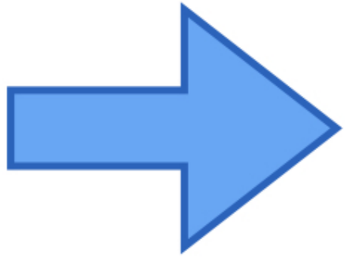


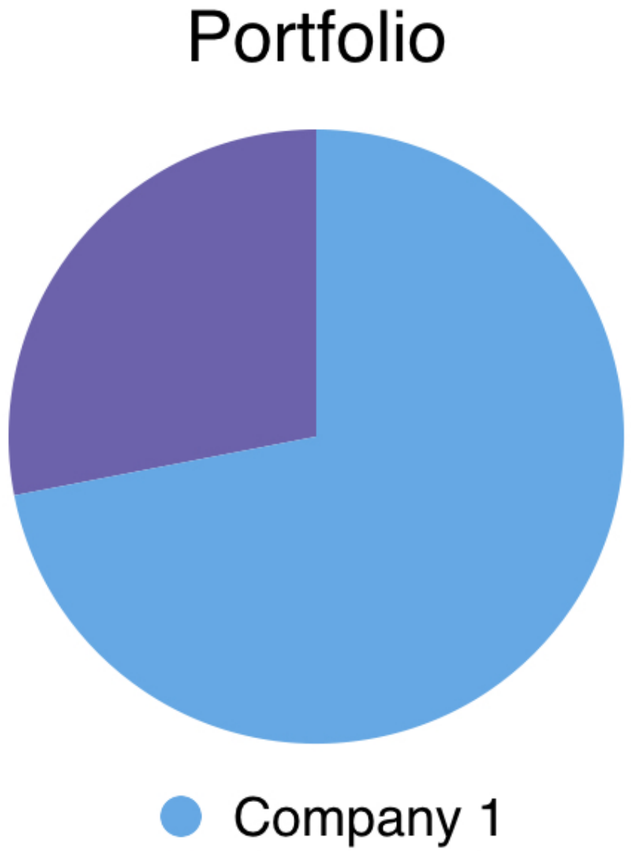
[1] Source: ICMA Photos, Flickr

Investment decision choices

There are two similar companies: Do you invest in either of them based on a coin toss?

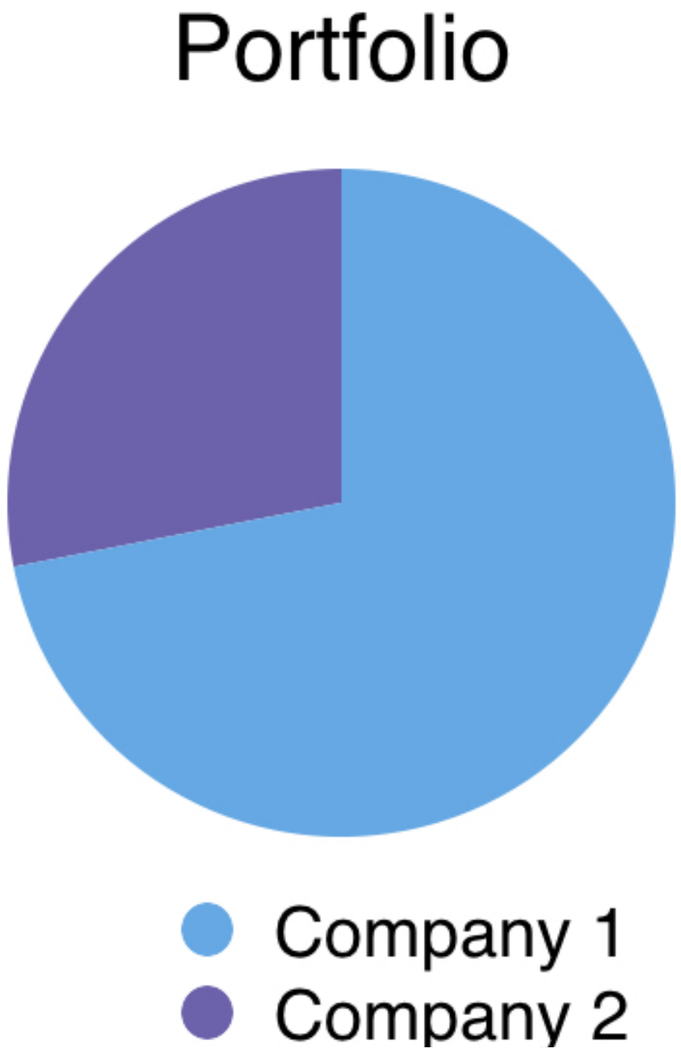




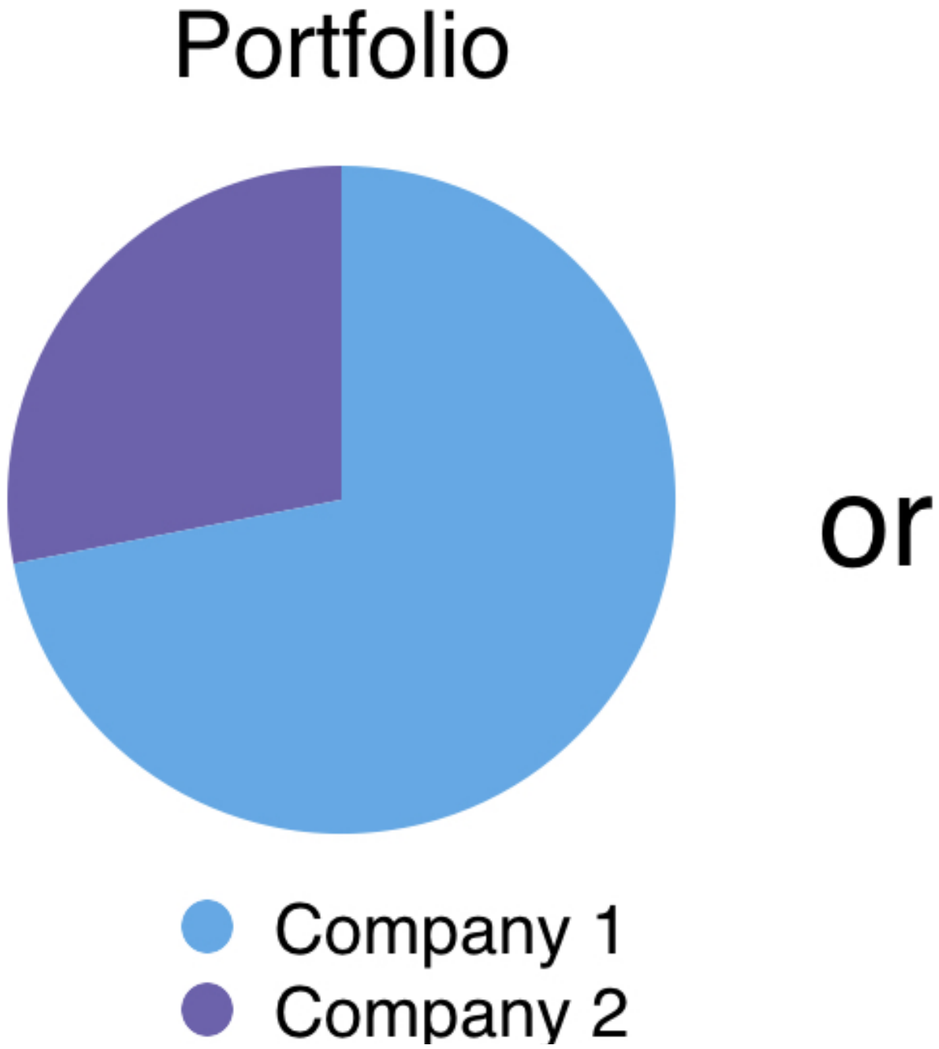


[1] Source: ICMA Photos, Flickr

Investment decision choices

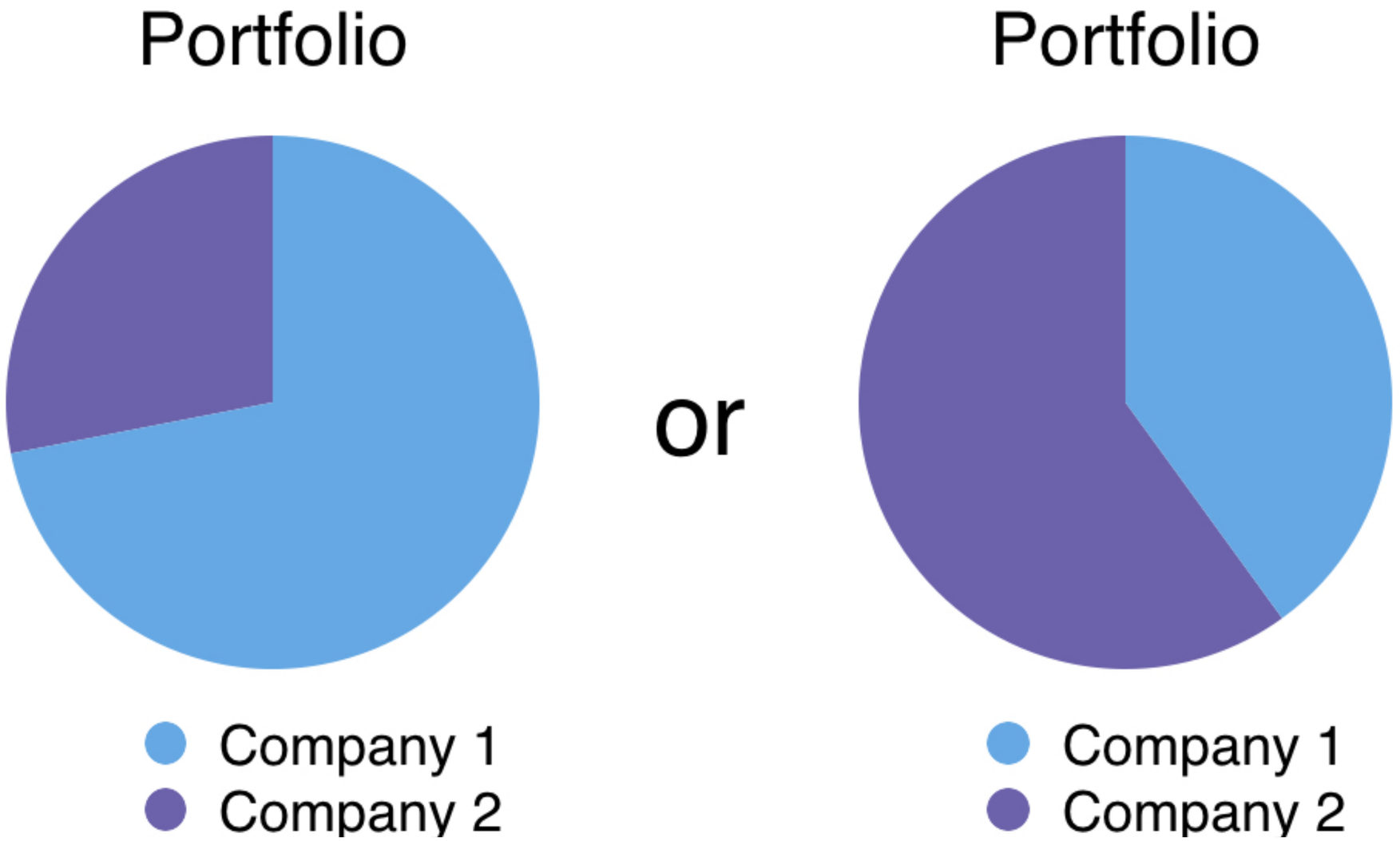


Investment decision choices

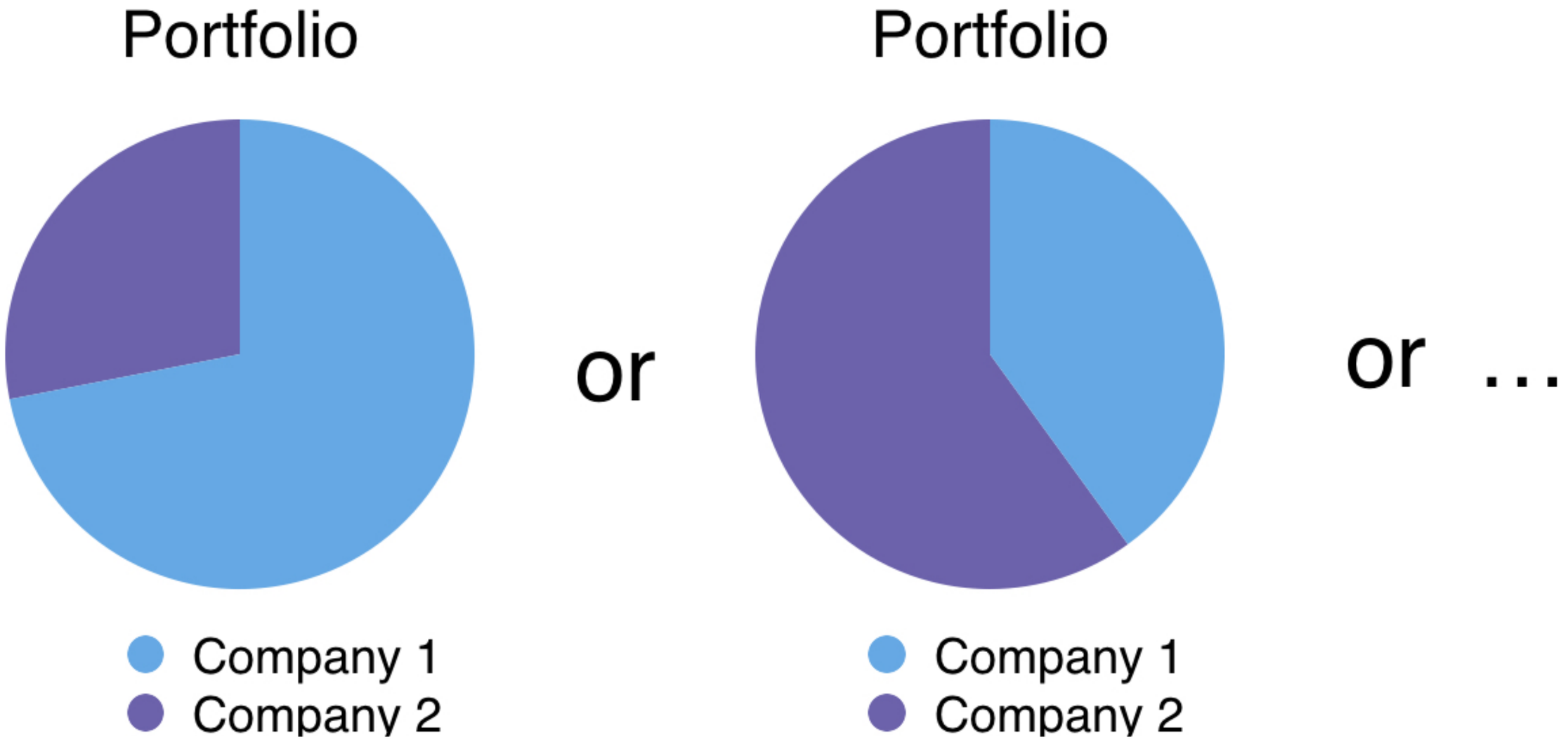


or

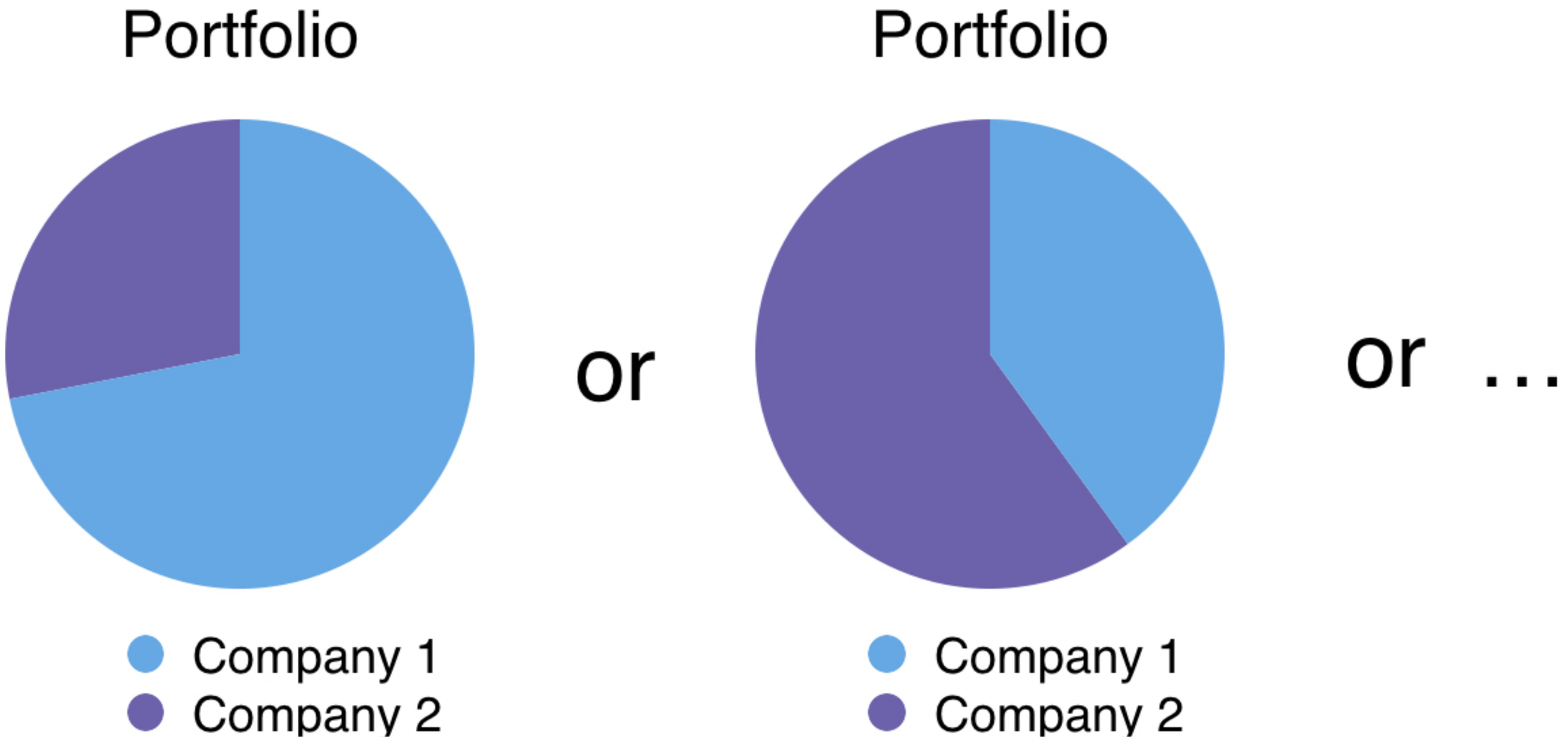
Investment decision choices



Investment decision choices



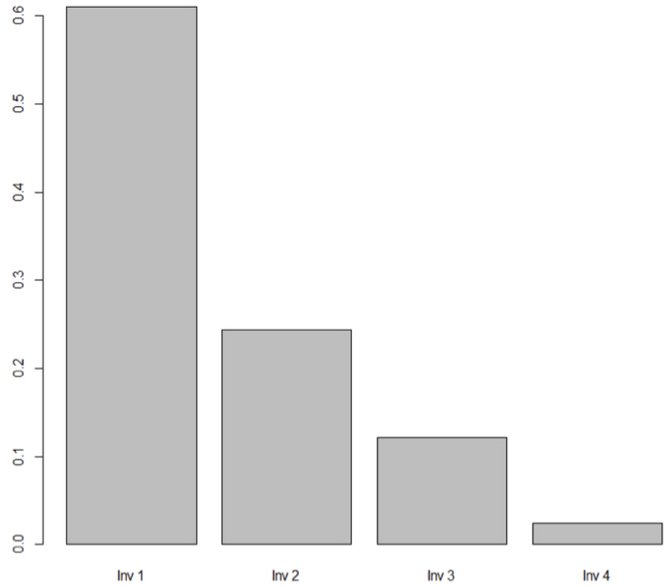
Investment decision choices



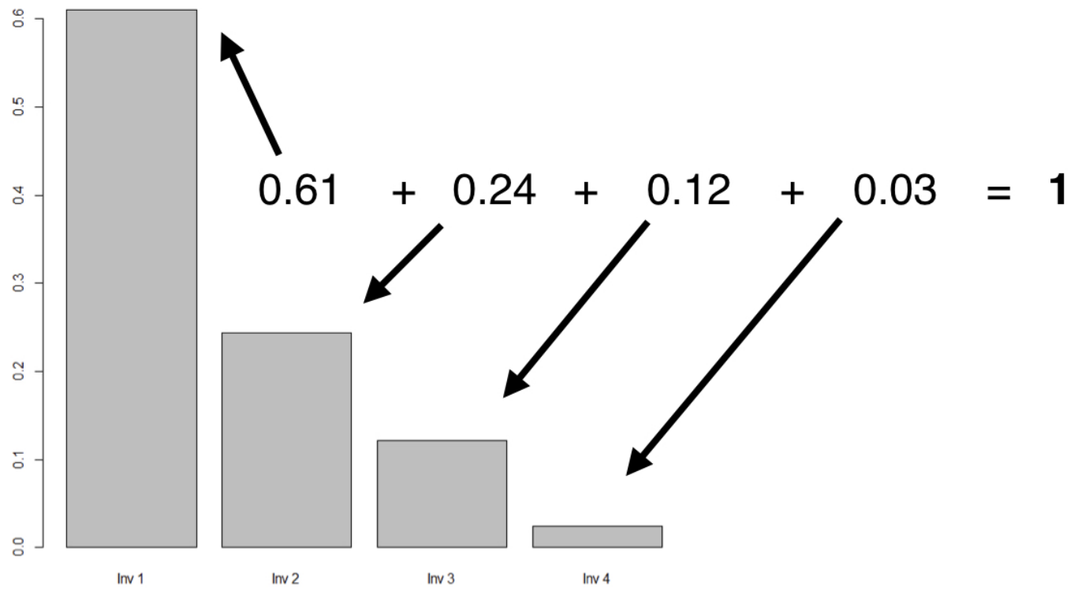
Asset weighting

Investment	Value Invested	Weight
1	V_1	$w_1 = \frac{V_1}{V_1 + \ldots + V_N}$
2	V_2	$w_2 = \frac{V_2}{V_1 + \ldots + V_N}$
⋮	⋮	⋮
N	V_N	$w_N = \frac{V_N}{V_1 + \ldots + V_N}$

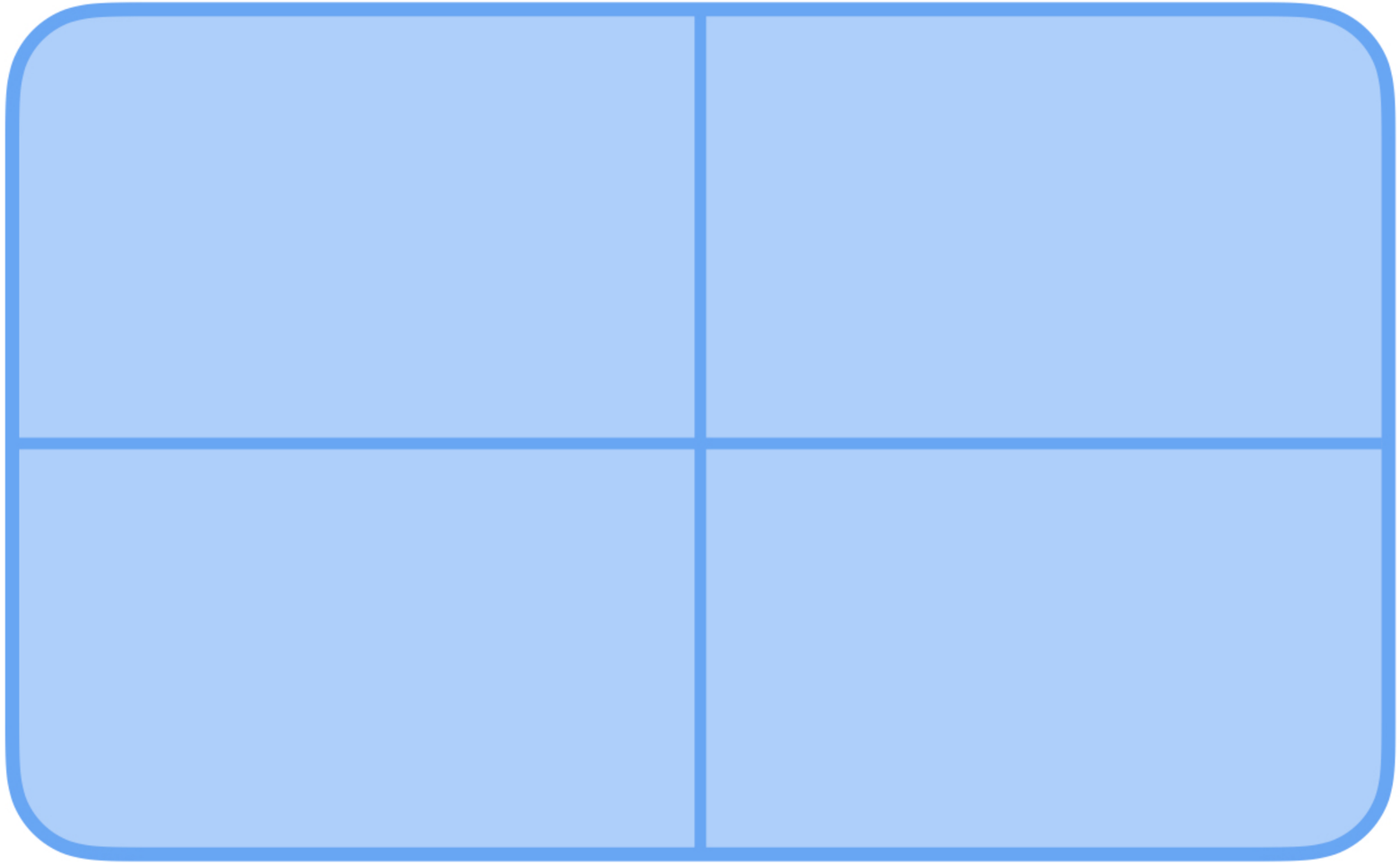
```
values <- c(500000, 200000, 100000, 20000)
names(values) <- c("Inv 1", "Inv 2", "Inv 3", "Inv 4")
weights <- values/sum(values)
barplot(weights)
```



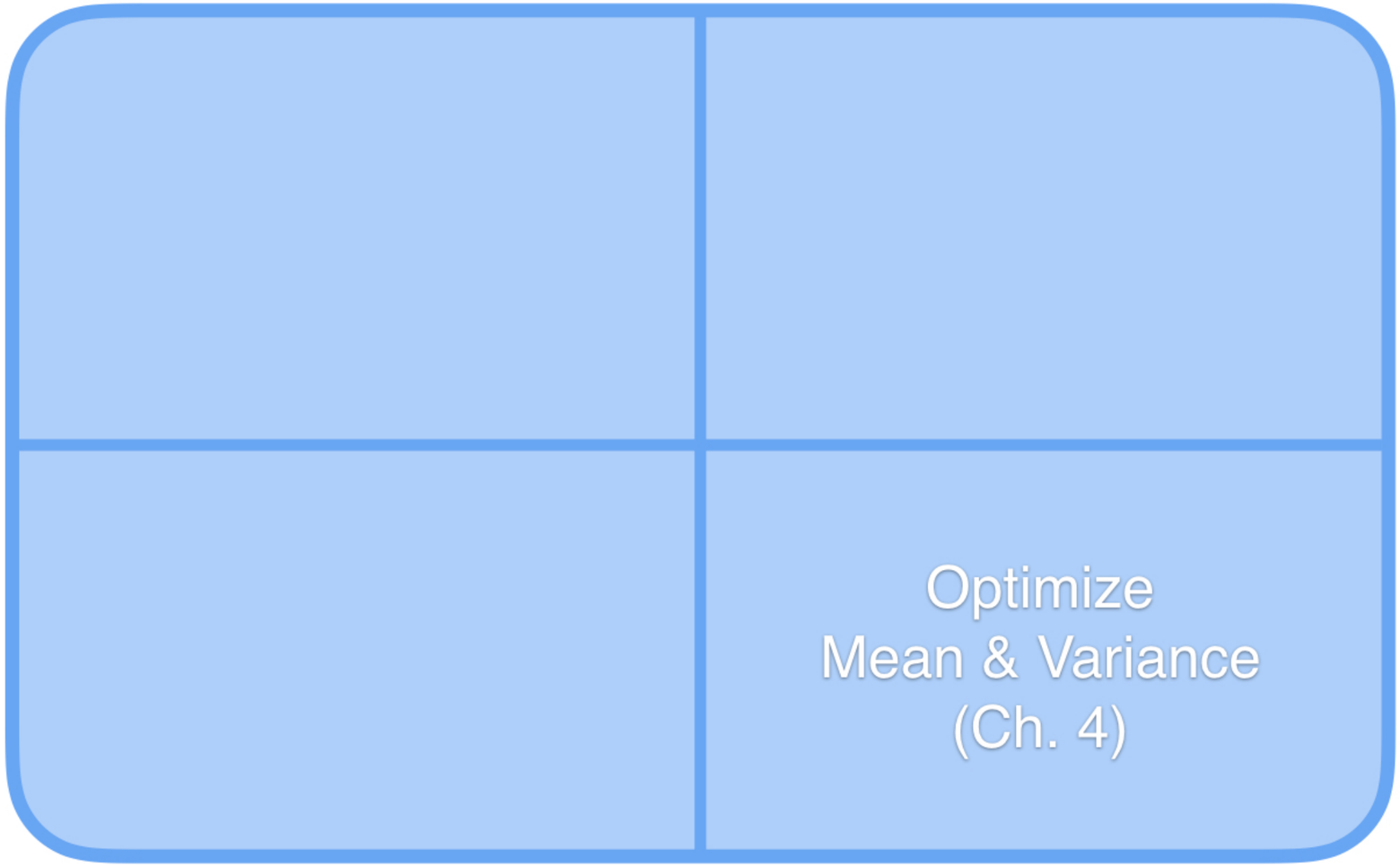
```
values <- c(500000, 200000, 100000, 20000)
names(values) <- c("Inv 1", "Inv 2", "Inv 3", "Inv 4")
weights <- values/sum(values)
barplot(weights)
```



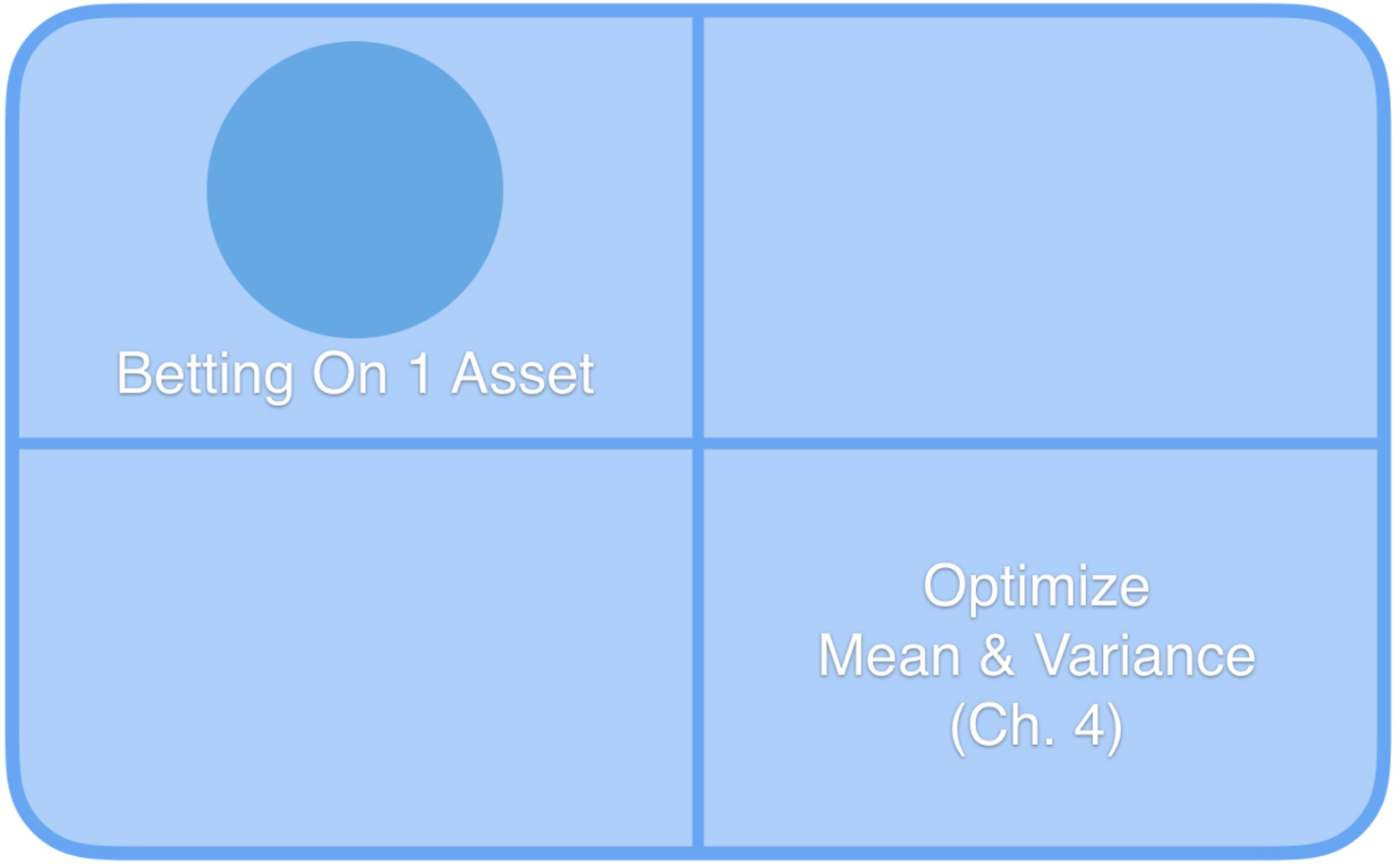
Allocation strategies



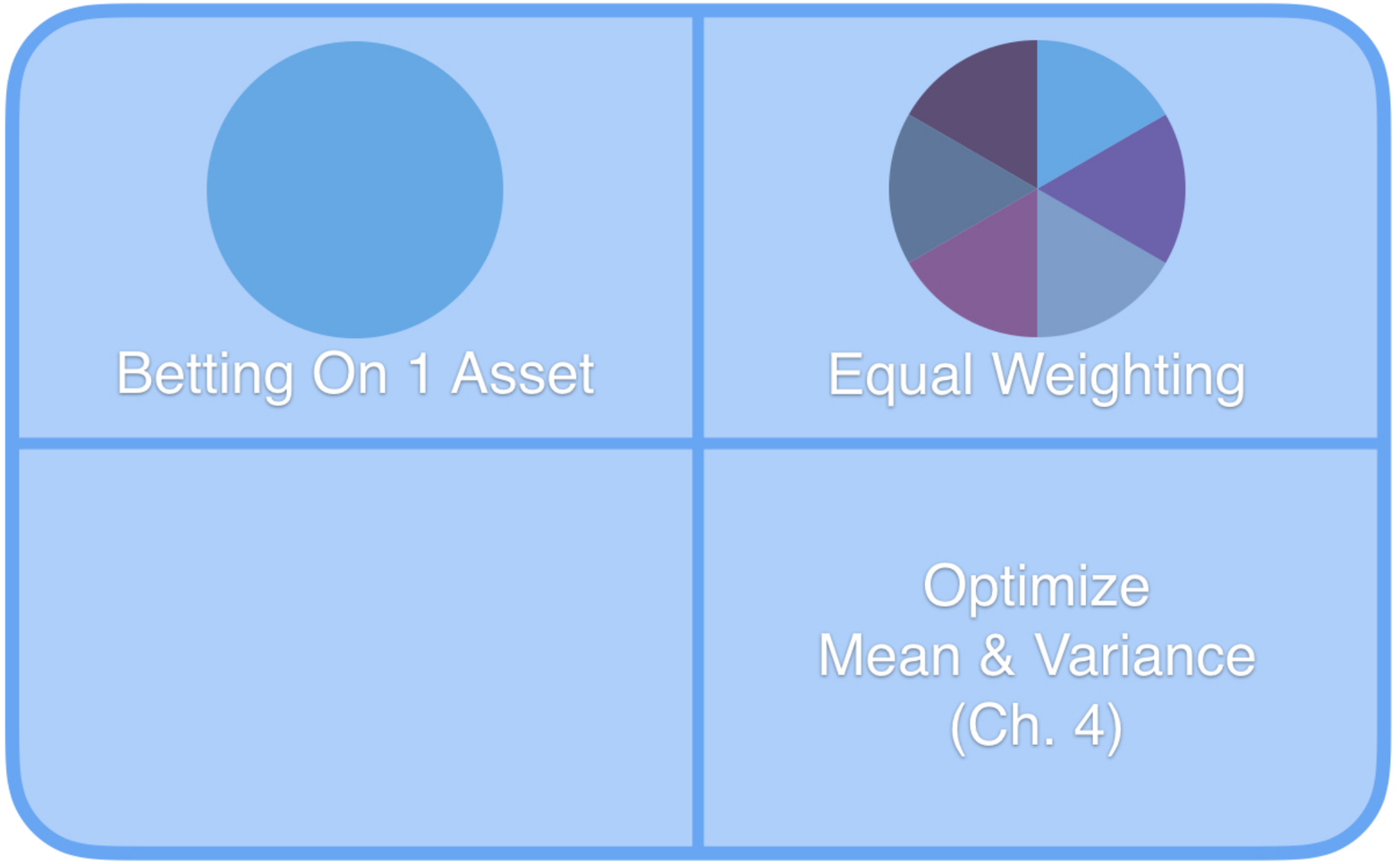
Allocation strategies



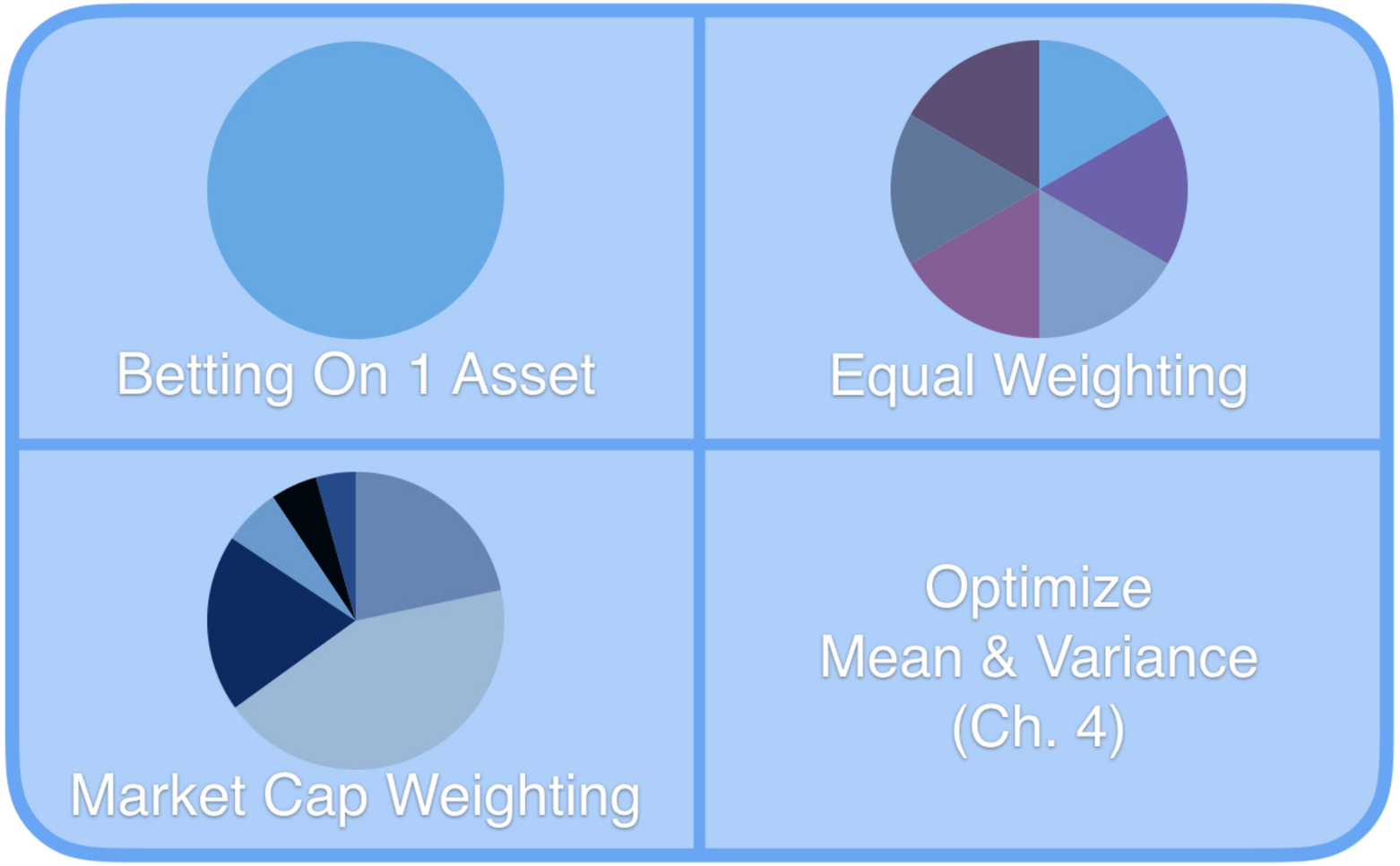
Allocation strategies



Allocation strategies



Allocation strategies



[1] Source: http://www.falibo.com/vocabulary/idiom-dont-put-all-your-eggs-in-one/

Let's practice!

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

The portfolio return

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

Kris Boudt

Professor, Free University Brussels & Amsterdam

datacamp

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Portfolio returns: relative value

- Weights reveal active investment bets
- Returns are the relative changes in value:

$$\frac{final\ value\ -\ initial\ value}{initial\ value}$$

Initial Value	100
Final Value	120

$$\frac{120 - 100}{100} = 20\%$$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

InValue.Portfolio = InValue.Asset$_1$ + … + InValue.Asset$_N$
FinValue.Portfolio = FinValue.Asset$_1$ + … + FinValue.Asset$_N$

$$Portfolio\ Return = \frac{FinValue.Portfolio - InValue.Portfolio}{InValue.Portfolio}$$

Example: two assets

$Asset_1$	$Asset_2$
$InValue.Asset_1 = \$200$	$InValue.Asset_2 = \$300$
$FinValue.Asset_1 = \$180$	$FinValue.Asset_2 = \$330$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

InValue.Portfolio = \$200 + \$300 = \$500
FinValue.Portfolio = \$180 + \$330 = \$510

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

InValue.Portfolio = \$200 + \$300 = \$500
FinValue.Portfolio = \$180 + \$330 = \$510

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

InValue.Portfolio = \$200 + \$300 = \$500
FinValue.Portfolio = \$180 + \$330 = \$510

$$Portfolio\ Return = \frac{FinValue.Portfolio - InValue.Portfolio}{InValue.Portfolio} = \frac{510-500}{500} = 2\%$$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

InValue.Portfolio = \$200 + \$300 = \$500
FinValue.Portfolio = \$180 + \$330 = \$510

$$Portfolio\ Return = \frac{FinValue.Portfolio - InValue.Portfolio}{InValue.Portfolio} = \frac{510-500}{500} = 2\%$$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

InValue.Portfolio = \$200 + \$300 = \$500
FinValue.Portfolio = \$180 + \$330 = \$510

$$Portfolio\ Return = \frac{FinValue.Portfolio - InValue.Portfolio}{InValue.Portfolio} = \frac{510-500}{500} = 2\%$$

Portfolio returns: weighted average return

$$Portfolio\ Return = w_1 R_1 + w_2 R_2 + ... + w_n R_n$$

Portfolio returns: weighted average return

$$Portfolio\ Return = w_1 R_1 + w_2 R_2 + ... + w_n R_n$$

Where: $$w_i = \frac{InValue.Asset_i}{\sum_{j=1}^{N} InValue.Asset_j}$$

Portfolio returns: weighted average return

$$Portfolio\ Return = w_1 R_1 + w_2 R_2 + ... + w_n R_n$$

Where:

$$w_i = \frac{InValue.Asset_i}{\sum_{j=1}^{N} InValue.Asset_j}$$

$$R_i = \frac{FinValue.Asset_i - InValue.Asset_i}{InValue.Asset_i}$$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Asset $_1$	Asset$_N$
$w_1 = \frac{InValue.Asset_1}{InValue.Portfolio}$	$w_n = \frac{InValue.Asset_n}{InValue.Portfolio}$
$R_1 = \frac{FinValue.\ Asset_1 - InValue.\ Asset_1}{InValue.\ Asset_1}$	$R_n = \frac{FinValue.\ Asset_n - InValue.\ Asset_n}{InValue.\ Asset_n}$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Asset $_1$	Asset$_N$
$w_1 = \frac{InValue.Asset_1}{InValue.Portfolio}$	$w_n = \frac{InValue.Asset_n}{InValue.Portfolio}$
$R_1 = \frac{FinValue.\ Asset_1 - InValue.\ Asset_1}{InValue.\ Asset_1}$	$R_n = \frac{FinValue.\ Asset_n - InValue.\ Asset_n}{InValue.\ Asset_n}$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Asset $_1$	Asset$_N$
$w_1 = \frac{InValue.Asset_1}{InValue.Portfolio}$	$w_n = \frac{InValue.Asset_n}{InValue.Portfolio}$
$R_1 = \frac{FinValue.\ Asset_1 - InValue.\ Asset_1}{InValue.\ Asset_1}$	$R_n = \frac{FinValue.\ Asset_n - InValue.\ Asset_n}{InValue.\ Asset_n}$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Asset $_1$	Asset$_N$
$w_1 = \frac{InValue.Asset_1}{InValue.Portfolio}$	$w_n = \frac{InValue.Asset_n}{InValue.Portfolio}$
$R_1 = \frac{FinValue.\ Asset_1 - InValue.\ Asset_1}{InValue.\ Asset_1}$	$R_n = \frac{FinValue.\ Asset_n - InValue.\ Asset_n}{InValue.\ Asset_n}$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Asset $_1$	Asset$_N$
$w_1 = \frac{InValue.Asset_1}{InValue.Portfolio}$	$w_n = \frac{InValue.Asset_n}{InValue.Portfolio}$
$R_1 = \frac{FinValue.\ Asset_1 - InValue.\ Asset_1}{InValue.\ Asset_1}$	$R_n = \frac{FinValue.\ Asset_n - InValue.\ Asset_n}{InValue.\ Asset_n}$

Three steps

Asset $_1$	…	Asset$_N$
InValue.Asset$_1$	…	InValue.Asset$_N$
FinValue.Asset$_1$	…	FinValue.Asset$_N$

Asset $_1$	Asset$_N$
$w_1 = \frac{InValue.Asset_1}{InValue.Portfolio}$	$w_n = \frac{InValue.Asset_n}{InValue.Portfolio}$
$R_1 = \frac{FinValue.\ Asset_1 - InValue.\ Asset_1}{InValue.\ Asset_1}$	$R_n = \frac{FinValue.\ Asset_n - InValue.\ Asset_n}{InValue.\ Asset_n}$

$$Portfolio\ Return = w_1R_1 + w_2R_2 + \ldots + w_nR_n$$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

Example: two assets

Asset $_1$	Asset$_2$
InValue.Asset$_1$ = \$200	InValue.Asset$_2$ = \$300
FinValue.Asset$_1$ = \$180	FinValue.Asset$_2$ = \$330

Asset $_1$	Asset$_2$
$w_1 = \frac{200}{500} = 40\%$	$w_2 = \frac{300}{500} = 60\%$
$R_1 = \frac{180 - 200}{200} = -10\%$	$R_2 = \frac{330 - 300}{300} = 10\%$

$$Portfolio\ Return = 0.4^*(-10\%) + 0.6^*(10\%) = 2\%$$

Let's practice!

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

PerformanceAnalytics

INTRODUCTION TO PORTFOLIO ANALYSIS IN R

Kris Boudt

Professor, Free University Brussels & Amsterdam

datacamp

The practitioner's challenge

- In practice, time series of portfolio returns
- Longer history → more info on portfolio
- Good package = `PerformanceAnalytics`

The creators

- `PerformanceAnalytics` is the go-to package for portfolio return analysis in R

Peter Carl

Brian Peterson

[1] https://tradeblotter.files.wordpress.com/2012/02/bwauthorpcc.jpeg

Calculating returns

- `Return.calculate` : to compute the asset returns
- `Return.portfolio` : to compute the portfolio return
- `Return.calculate(prices)`
  - `xts` -object
- Dates structure: `YYYY-MM-DD`

Calculating returns

- `Return.calculate`

```
returns <- Return.calculate(prices)
```

```
returns <- returns[(-1),]
```

```
head(prices)
```

```
AAPL   MSFT
2006-01-03 9.829465  21.07395
2006-01-04 9.858394  21.17603
2006-01-05 9.780810  21.19173
...
```

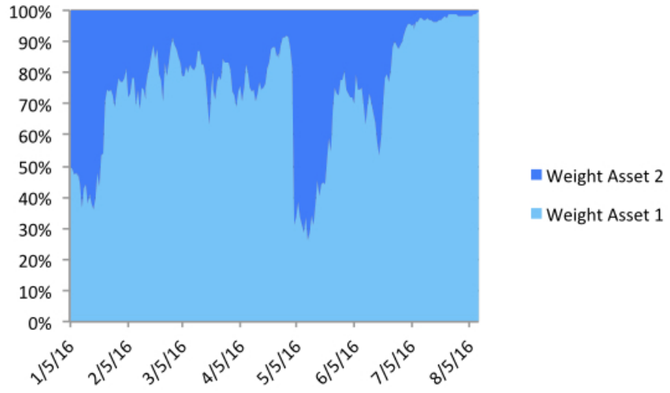
```
head(returns)
```

```
             AAPL          MSFT
2006-01-03   NA            NA
2006-01-04   0.002943090   0.0048434670
2006-01-05 -0.007869842   0.0007415934
...
```

Dynamics of portfolio weights

Set Initial Weights & Do Not Intervene

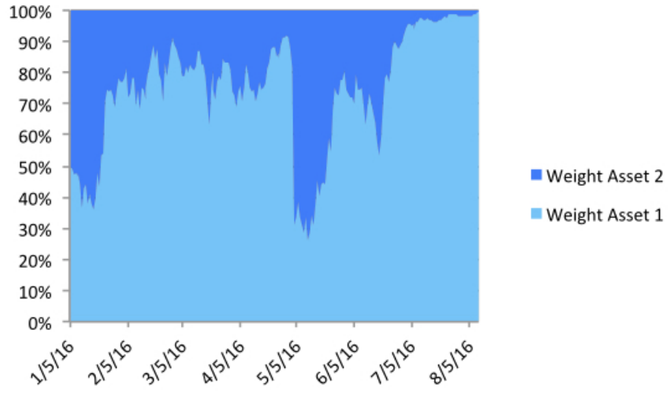
Example: Initial 50/50 weight



Dynamics of portfolio weights

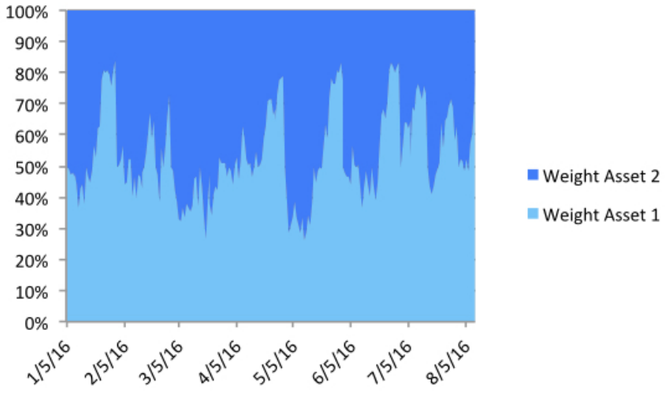
Set Initial Weights & Do Not Intervene

Example: Initial 50/50 weight



Actively Change Portfolio Weights

Example: 50/50 Weight With Rebalance



Portfolio returns

```
Return.portfolio <- function(R, weights = NULL,
    rebalance_on = c(NA, "years", "quarters",
                             "months", "weeks", "days"))
```

- Three arguments to be specified:
  - return data
  - weights
  - rebalancing

Let's practice!

INTRODUCTION TO PORTFOLIO ANALYSIS IN R