



Andreas Krause

Hedging with futures

# Levered investments and hedging

# Levered investments and hedging

- ▶ Futures and forwards can be used to obtain exposure to the underlying asset **without** purchasing it

# Levered investments and hedging

- ▶ Futures and forwards can be used to obtain exposure to the underlying asset without purchasing it, but investing only the premium

# Levered investments and hedging

- ▶ Futures and forwards can be used to obtain exposure to the underlying asset without purchasing it, but investing only the premium
- ▶ This often referred to as a **levered investment**

# Levered investments and hedging

- ▶ Futures and forwards can be used to obtain exposure to the underlying asset without purchasing it, but investing only the premium
- ▶ This often referred to as a levered investment
- ▶ Futures are also used to **eliminate the risk** from having exposure to the underlying asset

# Levered investments and hedging

- ▶ Futures and forwards can be used to obtain exposure to the underlying asset without purchasing it, but investing only the premium
- ▶ This often referred to as a levered investment
- ▶ Futures are also used to eliminate the risk from having exposure to the underlying asset
- ▶ Such a use of derivatives is called **hedging**

# Levered investments and hedging

- ▶ Futures and forwards can be used to obtain exposure to the underlying asset without purchasing it, but investing only the premium
- ▶ This often referred to as a levered investment
- ▶ Futures are also used to eliminate the risk from having exposure to the underlying asset
- ▶ Such a use of derivatives if called hedging

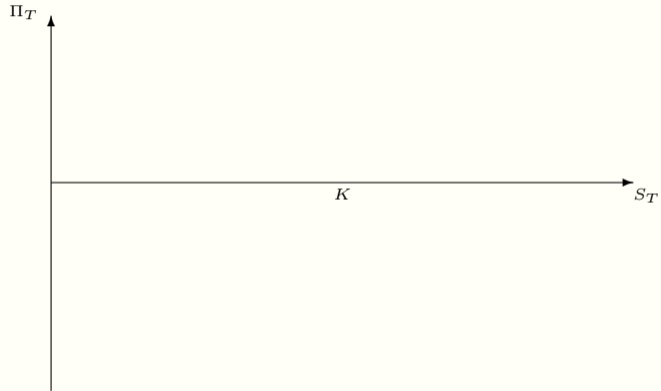


# Investor holding the underlying asset

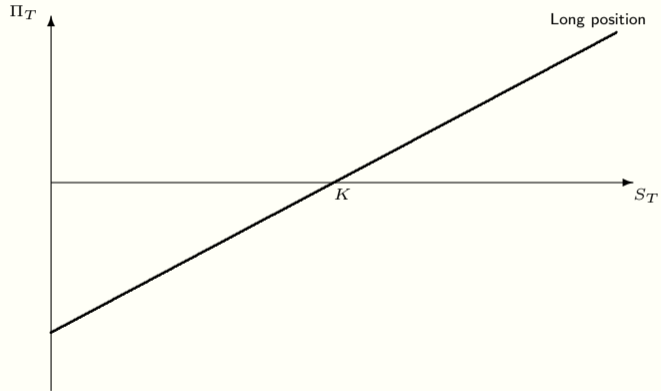
# Investor holding the underlying asset



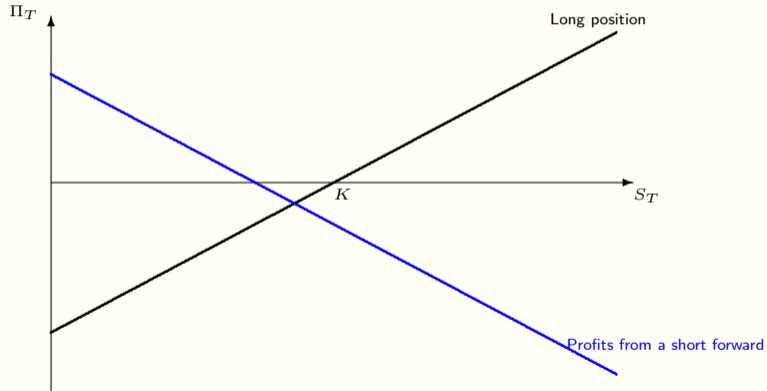
# Investor holding the underlying asset



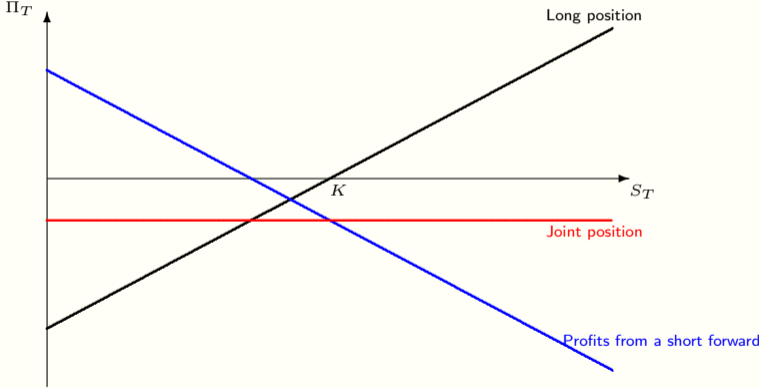
# Investor holding the underlying asset



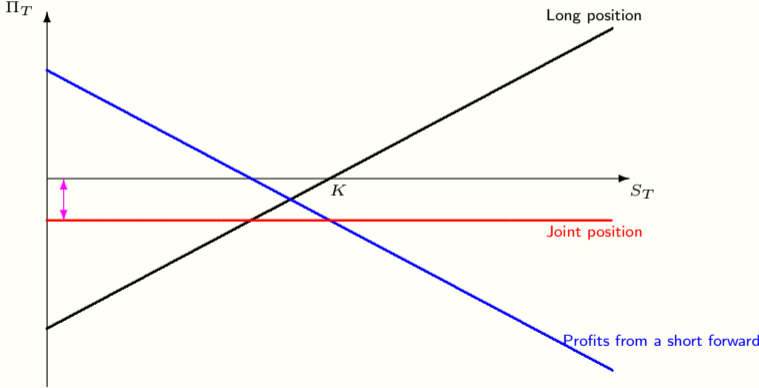
# Investor holding the underlying asset



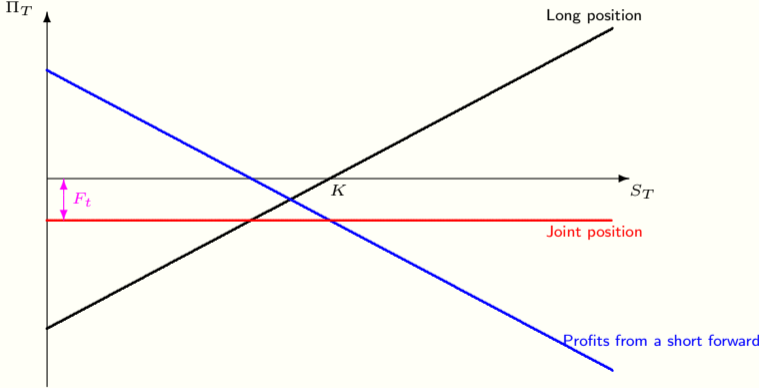
# Investor holding the underlying asset



# Investor holding the underlying asset

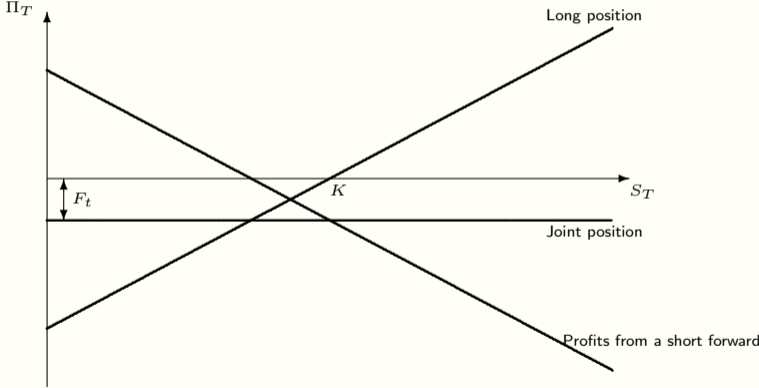


# Investor holding the underlying asset





# Investor holding the underlying asset

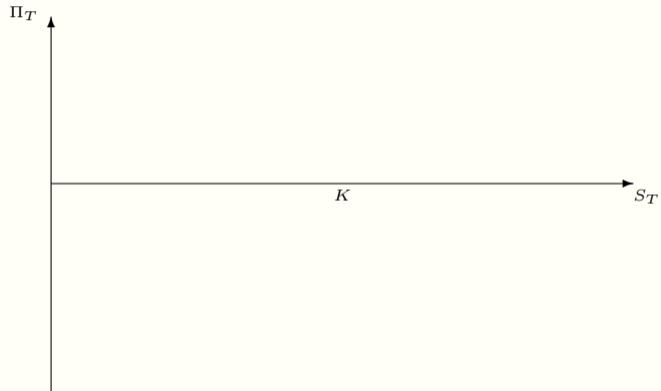


# Investor having to provide the underlying asset

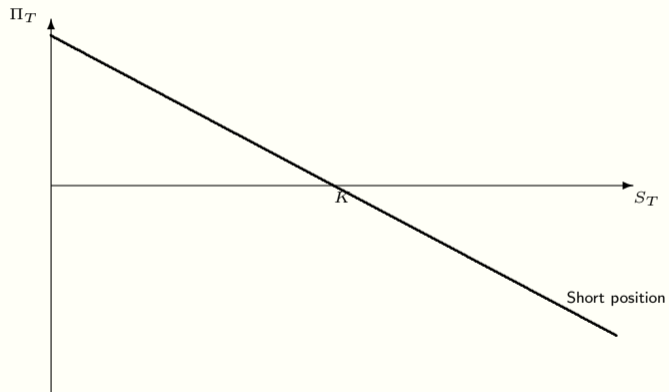
# Investor having to provide the underlying asset



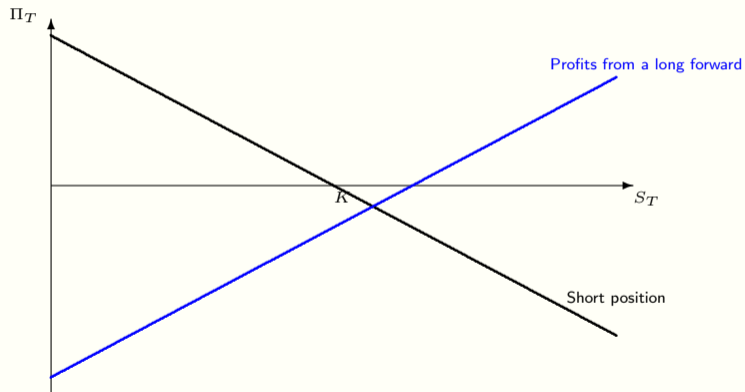
# Investor having to provide the underlying asset



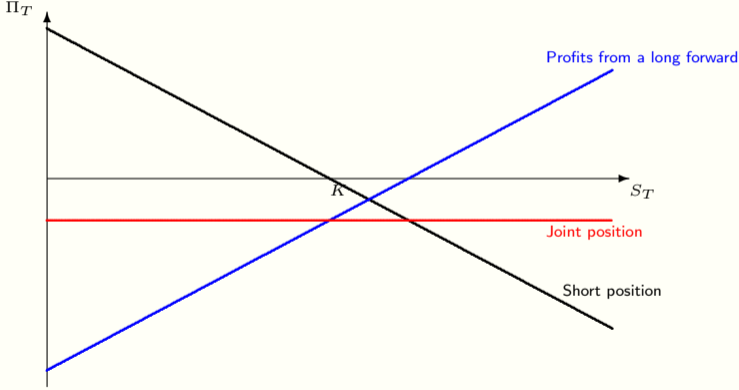
# Investor having to provide the underlying asset



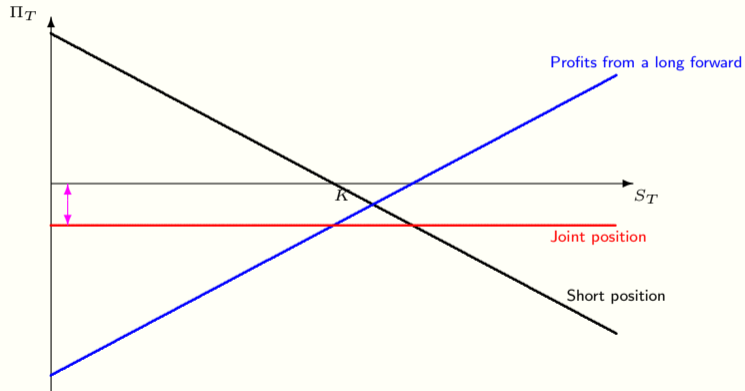
# Investor having to provide the underlying asset



# Investor having to provide the underlying asset

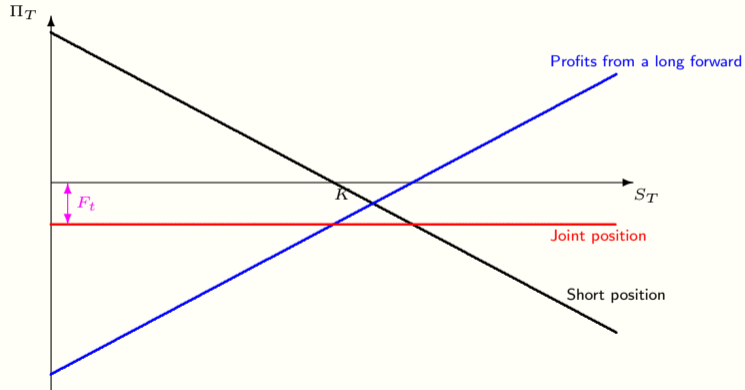


# Investor having to provide the underlying asset

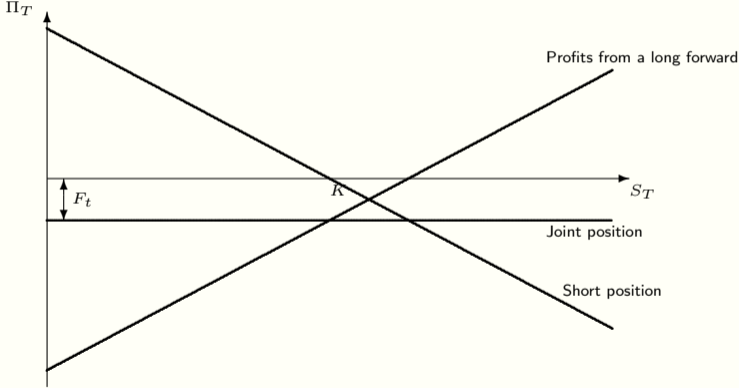




# Investor having to provide the underlying asset



# Investor having to provide the underlying asset



# Unavailability of futures and forwards

# Unavailability of futures and forwards

- ▶ Futures are **not always available** for the underlying asset desired

# Unavailability of futures and forwards

- ▶ Futures are not always available for the underlying asset desired
- ▶ Banks might not be willing to engage in **bespoke forwards** for the underlying asset desired

# Unavailability of futures and forwards

- ▶ Futures are not always available for the underlying asset desired
- ▶ Banks might not be willing to engage in bespoke forwards for the underlying asset desired
- ▶ This is a particular problem for stocks, where mostly only **stock index futures** are available

# Unavailability of futures and forwards

- ▶ Futures are not always available for the underlying asset desired
- ▶ Banks might not be willing to engage in bespoke forwards for the underlying asset desired
- ▶ This is a particular problem for stocks, where mostly only stock index futures are available
- ▶ Agreeing forwards for **specific portfolios** might be difficult

# Unavailability of futures and forwards

- ▶ Futures are not always available for the underlying asset desired
- ▶ Banks might not be willing to engage in bespoke forwards for the underlying asset desired
- ▶ This is a particular problem for stocks, where mostly only stock index futures are available
- ▶ Agreeing forwards for specific portfolios might be difficult
- ⇒ Investors agree a futures or forward contract in a **similar underlying asset**



# Unavailability of futures and forwards

- ▶ Futures are not always available for the underlying asset desired
- ▶ Banks might not be willing to engage in bespoke forwards for the underlying asset desired
- ▶ This is a particular problem for stocks, where mostly only stock index futures are available
- ▶ Agreeing forwards for specific portfolios might be difficult
- ⇒ Investors agree a futures or forward contract in a similar underlying asset

# Imperfect hedging

# Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a **different underlying asset**

# Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the **value of the asset**
- ▶  $\Pi_T = S_T$

# Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward
- ▶  $\Pi_T = S_T - F_T$

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
  - ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
  - ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var} [\Pi_T] = \text{Var} [S] - 2h\text{Cov} [S, F] + h^2\text{Var} [F]$

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$



## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$

# Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$
- ▶ This is known as the **hedge ratio**

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$
- ▶ This is known as the hedge ratio, detailing the **number of contracts** in the underlying asset for each asset sought to hedge

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$
- ▶ This is known as the hedge ratio, detailing the number of contracts in the underlying asset for each asset sought to hedge
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - \frac{\text{Cov}[S, F]^2}{\text{Var}[F]} > 0$

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$
- ▶ This is known as the hedge ratio, detailing the number of contracts in the underlying asset for each asset sought to hedge
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - \frac{\text{Cov}[S, F]^2}{\text{Var}[F]} > 0$
- ▶ The risk is **not eliminated**

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$
- ▶ This is known as the hedge ratio, detailing the number of contracts in the underlying asset for each asset sought to hedge
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - \frac{\text{Cov}[S, F]^2}{\text{Var}[F]} > 0$
- ▶ The risk is not eliminated, but **reduced**

## Imperfect hedging

- ▶ A long position in the asset is hedged with a number of short forward contracts on a different underlying asset
- ▶ The value at maturity of the forward is the value of the asset, less the value from the underlying asset of the forward, for each contract
- ▶  $\Pi_T = S_T - hF_T$
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - 2h\text{Cov}[S, F] + h^2\text{Var}[F]$
- ▶ We minimize the variance of the profits:  $\frac{\text{Var}[\Pi_T]}{\partial h} = 0$
- ⇒  $h = \frac{\text{Cov}[S, F]}{\text{Var}[F]}$
- ▶ This is known as the hedge ratio, detailing the number of contracts in the underlying asset for each asset sought to hedge
- ⇒  $\text{Var}[\Pi_T] = \text{Var}[S] - \frac{\text{Cov}[S, F]^2}{\text{Var}[F]} > 0$
- ▶ The risk is not eliminated, but reduced

# $\beta$ -hedging



- ▶ Assume the asset is a stock and the underlying asset of the forward the **stock market**

# $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]}$

# $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
  - ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
  - ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
  - ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- $\Rightarrow R_i = r + \beta_i (R_M - r) + \varepsilon_i$

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
  - ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
  - ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
  - ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- $\Rightarrow R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- $\Rightarrow \sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- ⇒  $R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- ⇒  $\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$
- ▶ The total risk of a stock consists of the **systematic risk**



## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- ⇒  $R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- ⇒  $\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$
- ▶ The total risk of a stock consists of the **systematic risk** and the **idiosyncratic risk**

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- $\Rightarrow R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- $\Rightarrow \sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$
- ▶ The total risk of a stock consists of the systematic risk and the idiosyncratic risk
- ▶  $\text{Var}[\Pi_T] = \sigma_{\varepsilon_i}^2$

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- ⇒  $R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- ⇒  $\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$
- ▶ The total risk of a stock consists of the systematic risk and the idiosyncratic risk
- ▶  $\text{Var}[\Pi_T] = \sigma_{\varepsilon_i}^2$
- ▶ Hedging using stock indices eliminates **systematic risk**

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- ⇒  $R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- ⇒  $\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$
- ▶ The total risk of a stock consists of the systematic risk and the idiosyncratic risk
- ▶  $\text{Var}[\Pi_T] = \sigma_{\varepsilon_i}^2$
- ▶ Hedging using stock indices eliminates systematic risk, but **not** idiosyncratic risk

## $\beta$ -hedging

- ▶ Assume the asset is a stock and the underlying asset of the forward the stock market
- ▶  $h = \frac{\text{Cov}[R_i, R_M]}{\text{Var}[R_M]} = \beta_i$
- ▶  $\text{Var}[\Pi_T] = \sigma_i^2 - \beta_i^2 \sigma_M^2$
- ▶ Assume the Capital Asset Pricing Model holds:  $\mu_i = r + \beta_i (\mu_M - r)$
- ⇒  $R_i = r + \beta_i (R_M - r) + \varepsilon_i$
- ⇒  $\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon_i}^2$
- ▶ The total risk of a stock consists of the systematic risk and the idiosyncratic risk
- ▶  $\text{Var}[\Pi_T] = \sigma_{\varepsilon_i}^2$
- ▶ Hedging using stock indices eliminates systematic risk, but not idiosyncratic risk



Copyright © by Andreas Krause

Picture credits:

Cover: Premier regard, Public domain, via Wikimedia Commons, [https://commons.wikimedia.org/wiki/File:DALL-E\\_-\\_Financial\\_markets\\_\(1\).jpg](https://commons.wikimedia.org/wiki/File:DALL-E_-_Financial_markets_(1).jpg)

Back: Rhododendrites, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons, [https://upload.wikimedia.org/wikipedia/commons/0/04/Manhattan\\_at\\_night\\_south\\_of\\_Rockefeller\\_Center\\_panorama\\_\(11263p\).jpg](https://upload.wikimedia.org/wikipedia/commons/0/04/Manhattan_at_night_south_of_Rockefeller_Center_panorama_(11263p).jpg)

Andreas Krause  
Department of Economics  
University of Bath  
Claverton Down  
Bath BA2 7AY  
United Kingdom

E-mail: [mnsak@bath.ac.uk](mailto:mnsak@bath.ac.uk)