



PORTFOLIO MANAGEMENT

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Economics and Investment Markets

Study Session 17

Reading Number 49



LOS 49.a: Explain the notion that to affect market values, economic factors must affect one or more of the following: 1) default-free interest rates across maturities, 2) the timing and/or magnitude of expected cash flows, and 3) risk premiums

- The value of an asset can be computed as the present value of its expected future cash flows discounted at an appropriate risk-adjusted discount rate
- The more uncertain the cash flows, the higher the discount rate
- Components of the discount rate are:
 1. Real risk-free discount rate (R)
 2. Expected inflation (π)
 3. Risk premium reflecting the uncertainty about the cash flow (RP)
- The value of an asset will change if either the cash flow forecasts change or any of the components of the discount rate changes
- Risk premium varies across assets and also varies with changes in investors' perception of risk



LOS 49.b: Explain the role of expectations and changes in expectations in market valuation

- The value of an asset depends on (1) its expected future cash flows and (2) the discount rate used to value those cash flows
- As market participants receive new information, the timing and amount of expected future cash flows are revised and valuations change as a result
- The impact of new information will depend on its effect on current expectations

LOS 49.c: Explain the relationship between the long-term growth rate of the economy, the volatility of the growth rate, and the average level of real short-term interest rates

- The real risk-free rate of interest derives from the inter-temporal rate of substitution, which represents an investor's trade-off between real consumption now and real consumption in the future

$$\text{Inter-temporal rate of substitution} = m_t = \frac{\text{marginal utility of consuming 1 unit in the future}}{\text{marginal utility of current consuming of 1 unit}} = \frac{u_t}{u_0}$$

$u_0 > u_t$ as investors always prefer current consumption over future consumption, therefore $m_t < 1$

- Considering m_t , the current price of a zero-coupon, inflation-indexed, risk-free bond that will pay \$1 at time t can be expressed as:

$$P_0 = E(m_t)$$

- In which case, the real risk-free rate of return is:

$$R = \frac{1 - P_0}{P_0} = \left[\frac{1}{E(m_t)} \right] - 1$$



The lower the expected m_t ($u_0 \gg u_t$) the higher the risk-free rate of return



Recall: Price of a zero-coupon bond $P_0 = \frac{1}{(1+R)}$

LOS 49.c: Explain the relationship between the long-term growth rate of the economy, the volatility of the growth rate, and the average level of real short-term interest rates

Some key points to keep in mind

- The higher the utility investors attach for current consumption relative to future consumption, the higher the real rate
- An investor marginal utility of consumptions declines as wealth increases (this effect is known as *diminishing marginal utility of wealth*). This suggests that marginal utility of consumption is higher during periods of scarcity, such as during economic contractions
- If investors expect higher incomes in the future (improving economy expectations), their expected marginal utility of future consumption is decreased relative to current consumption. This will lead to an increase of current consumption and a decrease on savings. Conversely, investors expecting worse times ahead would prefer to increase future consumption by reducing current consumption
- Investors increase their savings rate when expected returns are high or when uncertainty about their future income increases

LOS 49.c: Explain the relationship between the long-term growth rate of the economy, the volatility of the growth rate, and the average level of real short-term interest rates

Risky Cash Flows and Risk Premiums

- If the underlying cash flows are uncertain, investors demand a risk premium for bearing the risk.
- Investors experience a larger loss of utility for a loss in wealth as compared to a gain in utility for an equivalent gain in wealth. This property is called **risk-aversion**
- Absolute risk aversion declines with wealth. However, the marginal utility of holding risky assets declines as an investor holds more risky assets in her portfolio. When the market are in equilibrium, wealthy and poorer investors would have the same willingness to hold risky assets
- Consider a risk-free, inflation indexed, zero coupon bond, that an investor will sell prior to maturity. The uncertainty about the sale gives rise a risk premium. The price of the bond will be lower than the expected sale price discounted at the real risk free rate. We can model this risk premium as:

$$P_0 = \frac{E(P_1)}{(1+R)} + \text{cov}(P_1, m_1)$$

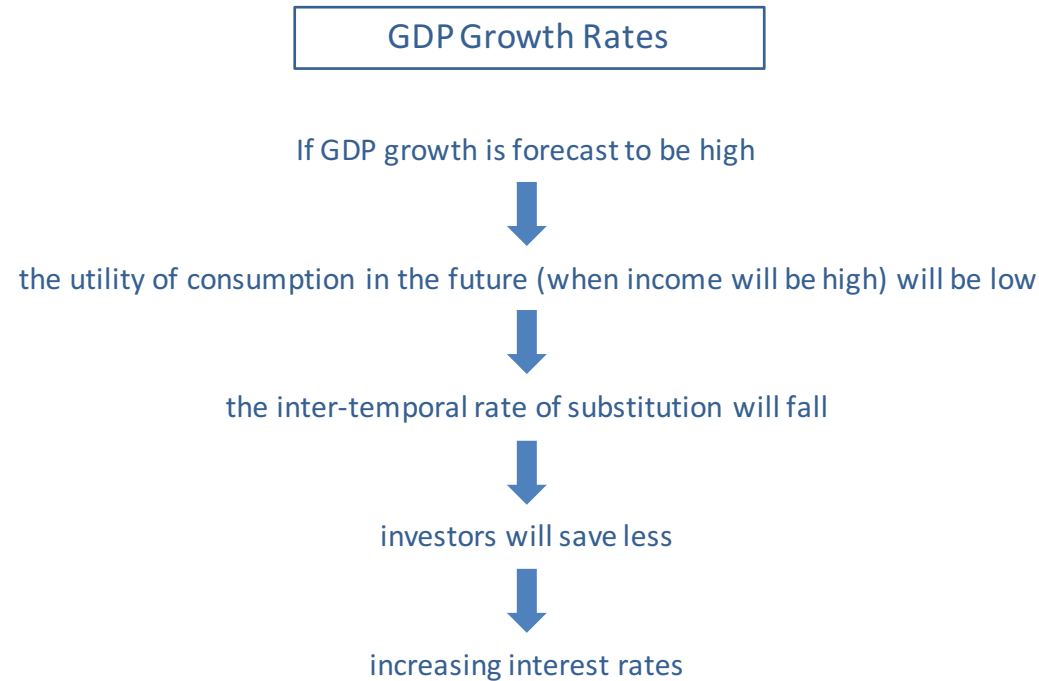
Risk-free discount factor

Risk aversion premium

- $\text{cov}(P_1, m_1)$: is the covariance of an investor's inter-temporal marginal rate of substitution and expected returns on savings and can be viewed as the risk aversion of an investor (risk premium)
- **For risk averse investors, the covariance is negative** (when the expected future price of the asset is high, the marginal utility of future consumption relative to current consumption is low – this is due to expectations of good economic times-)
- R: the real risk-free rate

The lower current price (P_0) increases expected return. This higher expected return is due to a positive risk premium

LOS 49.c: Explain the relationship between the long-term growth rate of the economy, the volatility of the growth rate, and the average level of real short-term interest rates



Therefore real interest rates are positively correlated with GDP growth rates

Interest rates are also positively correlated with the expected volatility in GDP growth due to higher risk premium

LOS 49.d: Explain how the phase of the business cycle affects policy and short-term interest rates, the slope of the term structure of interest rates, and the relative performance of bonds of differing maturities

➤ **Nominal risk-free interest rates** include a premium for expected inflation (π)

Short term risk-free securities	➡	$r \text{ (short-term)} = R + \pi$	$\left\{ \begin{array}{l} r: \text{nominal interest rate} \\ R: \text{real risk-free rate} \\ \pi: \text{expected inflation} \\ \theta: \text{risk premium for the uncertainty of inflation} \end{array} \right.$
Long term risk-free securities	➡	$r \text{ (long-term)} = R + \pi + \theta$	

➤ **Taylor Rule** ➡ Links the central bank's policy rate to economic conditions (employment level and inflation)

$r = R_n + \pi + 0,5(\pi - \pi^*) + 0,5(y - y^*)$	$\left\{ \begin{array}{l} r: \text{central bank policy rate implied by the Taylor rule} \\ R_n: \text{neutral real policy interest rate} \\ \pi: \text{current inflation rate} \\ \pi^*: \text{central bank's target inflation rate} \\ y: \text{log of current level of output} \\ y^*: \text{log of central bank's target (sustainable) output} \end{array} \right.$
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Central banks can moderate the business cycle by making appropriate changes to the policy rate or can magnify the cycle by not responding appropriately to changing economic conditions



LOS 49.d: Explain how the phase of the business cycle affects policy and short-term interest rates, the slope of the term structure of interest rates, and the relative performance of bonds of differing maturities

Business Cycle and Slope of the Yield Curve

- When economy is in recession, short term policy rates tend to be low
- Investors expectations about higher future GDP growth and inflation as the economy comes out of recession lead to higher longer-term rates. This lead to positive slope of yied curve
- Conversely, an inversely sloping yield curve (inverted yield curve) is often considered a predictor of future recessions



LOS 49.e: Describe the factors that affect yield spreads between non-inflation-adjusted and inflation-indexed bonds

Break-Even Inflation rate (BEI) = yield on non-inflation-indexed bond – yield on inflation-indexed bond

- Recall that for longer maturity bonds, the nominal rate is composed of the real rate, expected inflation, and a risk premium for inflation uncertainty

$$r \text{ (long-term)} = R + \pi + \theta$$

- BEI is composed of two elements: expected inflation (π) and a risk premium for the uncertainty about inflation (θ)

$$\text{BEI} = \pi + \theta$$

LOS 49.f: Explain how the phase of the business cycle affects credit spreads and the performance of credit-sensitive fixed-income instruments

- The required rate of return for bonds with credit risk includes an additional risk premium. This risk premium is the **credit spread** and is the difference in yield between a credit risky bond and a default-free bond of the same maturity

$$\text{Required rate of return for credit risky bonds} = R + \pi + \theta + \gamma$$

γ : additional risk premium for credit risk = credit spread

- Credit spreads tend to rise during times of economic downturns and fall during expansions
- When credit spreads narrow (expansions), lower-rated bonds tend to outperform higher-rated bonds. Conversely, when credit spreads widen (economic downturns), higher rated bonds will outperform lower rated bonds



LOS 49.g: Explain how the characteristics of the markets for a company's products affect the company's credit quality

- Spreads for issuers in consumer cyclical sector widen considerably during economic downturns compared to spreads for issuers in the consumer non-cyclical sector



LOS 49.h: Explain how the phase of the business cycle affects short-term and long-term earnings growth expectations

- Cyclical industries tend to be extremely sensitive to the business cycle; their earnings rise during economic expansions and fall during contractions
- Non-cyclical or defensive industries tend to have relative stable earnings

LOS 49.i: Explain the relationship between the consumption-hedging properties of equity and the equity risk premium

- The discount rate used to value equity securities includes an additional risk premium, the equity risk premium
- The risk premium is in addition to the risk premium on credit risky bonds because equity is more risky than debt

$$\text{Discount rate for equity} = R + \pi + \theta + \gamma + \kappa$$

κ : additional risk premium relative to risky debt for an investment in equities
 λ : equity risk premium = $\gamma + \kappa$

- Assets that provide a higher payoff during economic downturns are more highly value because of the *consumption hedging property* of the asset. This property reduces the risk premium on an asset
- Equities are generally cyclical; they have higher values during good times and have poor consumption hedging properties. Because of this poor consumption hedging ability, equity risk premium is positive



LOS 49.j: Describe cyclical effects on valuation multiples

- Price multiples (e.g., P/E, P/B...) are positively correlated with expected earnings growth rates and negatively correlated to required returns
- Therefore, price multiples rise with increases in expected future earnings growth and with a decrease in any of the components of the required rate of return (real rate, expected inflation, the risk premium for inflation uncertainty, or the equity risk premium)
- Price multiples tend to follow the business cycle: multiple rise during economic expansions (as analysts revise growth estimates upward) and fall during contractions (as growth estimates are revised downward)



LOS 49.k: Describe the implications of the business cycle for a given style strategy (value, growth, small capitalization, large capitalization)

- **Growth stocks** are characterized by high P/E ratios and by low dividend yields and tend to be in immature markets with high growth prospects
- **Value stocks** tend to have low P/E ratios, high dividend yields and are generally found in established and mature markets. Value stocks tend to have stable earnings
- A value strategy performs well during recessionary conditions, while growth strategy performs well during economic expansions
- Stocks are also categorized by company size as measured by market capitalization (e.g., small-cap, mid-cap, and large-cap)
- Small-cap stocks tend to have higher volatility and command a higher risk premium



LOS 49.I: Describe how economic analysis is used in sector rotation strategies

- Ex post risk premiums on equity sectors can be computed as the difference between the average return on a sector and the short-term risk free rate
- Relative outperformance of sectors can be therefore discerned ex post
- Ex ante forecasting of this outperformance is the objective of active managers
- Investors could rotate out the under-performing sector into the better performing sector to generate superior returns. Getting the timing right is, of course, very difficult

LOS 49.m: Describe the economic factors affecting investment in commercial real estate

Commercial real estate investments have:

- Bond-like characteristics → steady rental income stream similar to cash flows from a portfolio of bonds
- Equity-like characteristics → the value of commercial real estate is influenced by many factors (state of economy, demand for rental properties and property location)
- Illiquidity → Real estate as an asset class is characterized by illiquidity

LOS 49.m: Describe the economic factors affecting investment in commercial real estate

Valuation

- When estimating the value of real estate investment, the discount rate includes an additional risk premium for the lack of liquidity

$$\text{Discount rate for commercial real estate} = R + \pi + \theta + \gamma + \kappa + \phi$$

κ : risk premium for uncertainty about terminal value of property (similar to equity risk premium)
 ϕ : risk premium for illiquidity

- Commercial property values tend to be very cyclical. Because of this, the correlation of commercial property values with those of other asset classes (e.g., equities) tends to be positive
- Similar to equities, real estate provides a poor hedge against bad consumption outcomes



Analysis of Active Portfolio Management

Study Session 17

Reading Number 50

LOS 50.a: Describe how value added by active management is measured

Active management seeks to add value by outperforming a passively managed benchmark portfolio

Active Return (R_A) ➡ Is the value added by active management

$$E(R_A) = E(R_P) - E(R_B)$$

or

$$E(R_A) = \sum \Delta w_i E(R_i)$$

$E(R_A)$: Ex-ante active return

$E(R_P)$: Expected return of an actively managed portfolio

$E(R_B)$: Expected return of its benchmark

➡ $E(R_P) = \sum w_{Pi} E(R_i)$

➡ $E(R_B) = \sum w_{Bi} E(R_i)$

$E(R_A)$: Ex-ante active return

Δw_i : active weight = $w_{Pi} - w_{Bi}$ (weight of security i in portfolio minus weight of security i in benchmark)

$E(R_i)$: Expected return of security i

Observe: active weights must sum zero

Ex-post active return is the difference between the realized return of the actively managed portfolio and its benchmark portfolio

LOS 50.a: Describe how value added by active management is measured

EXAMPLE: Active return

The following information is available for an actively managed portfolio and its benchmark.

Security (i)	Portfolio Weight (W_{Pi})	Benchmark Weight (W_{Bi})	Expected Return $E(R_i)$
A	22%	25%	12%
B	20%	25%	-6%
C	21%	25%	4%
D	37%	25%	19%

Calculate the ex-ante active return.

Answer:

$$\text{Active return} = E(R_P) - E(R_B)$$

$$E(R_P) = \sum w_{Pi} (R_i) = (0.22)(0.12) + (0.20)(-0.06) + (0.21)(0.04) + (0.37)(0.19) \\ = 0.0931 \text{ or } 9.31\%$$

$$E(R_B) = \sum w_{Bi} (R_i) = (0.25)(0.12) + (0.25)(-0.06) + (0.25)(0.04) + (0.25)(0.19) \\ = 0.0725 \text{ or } 7.25\%$$

$$E(R_A) = 0.0931 - 0.0725 = 0.0206 \text{ or } 2.06\%$$

Alternatively:

Security (i)	Portfolio Weight (W_{Pi})	Benchmark Weight (W_{Bi})	Return R_i	Active Weight (ΔW_i)
A	22%	25%	12%	-3%
B	20%	25%	-6%	-5%
C	21%	25%	4%	-4%
D	37%	25%	19%	12%

$$E(R_A) = \sum \Delta w_i E(R_i) = (-0.03)(0.12) + (-0.05)(-0.06) + (-0.04)(0.04) + (0.12)(0.19) = 2.06\%$$

LOS 50.a: Describe how value added by active management is measured

Active return is composed of two parts:

- 1.- **Asset allocation return** (from deviation of asset class portfolio weights from benchmark weights)
- 2.- **Security selection return** (from active returns within asset classes)

$$E(R_A) = \underbrace{\sum \Delta w_i E(R_{B,i})}_{\text{Active return due to asset allocation}} + \underbrace{\sum w_{P,i} E(R_{A,i})}_{\text{Active return due to security selection}}$$

Active return due to
asset allocation

Active return due to
security selection

$E(R_{P,i})$ = expected return of asset class “i” in portfolio

$E(R_{B,i})$ = expected return of asset class “i” in benchmark

$E(R_{A,i})$ = expected active return within asset classes = $E(R_{P,i}) - E(R_{B,i})$

LOS 50.a: Describe how value added by active management is measured

EXAMPLE: Active return

Optoma Fund invests in three asset classes: U.S. equities, U.S. bonds, and international equities. The asset allocation weights of Optoma and the expected performance of each asset class and the benchmark are shown in the following table.

Asset Class (i)	Portfolio Weight (W_{Pi})	Benchmark Weight (W_{Bi})	Portfolio Return $E(R_{Pi})$	Benchmark Return $E(R_{Bi})$
U.S. equities	45%	40%	11%	12%
U.S. bonds	30%	30%	6%	5%
International Equities	25%	30%	14%	12%

Calculate the expected active return.

Answer:

Asset Class (i)	Portfolio Weight (W_{Pi})	Benchmark Weight (W_{Bi})	Portfolio Return $E(R_{Pi})$	Benchmark Return $E(R_{Bi})$	Active Weight (ΔW_i)
U.S. equities	45%	40%	11%	12%	5%
U.S. bonds	30%	30%	6%	5%	0%
International Equities	25%	30%	14%	12%	-5%
Total					

Asset Class (i)	$(\Delta W_i) \times E(R_{Bi})$	$\frac{E(A_i)}{E(R_{Pi}) - E(R_{Bi})}$	$(W_{Pi}) \times E(A_i)$
U.S. equities	0.60%	-1%	-0.45%
U.S. bonds	0.00%	1%	0.30%
International Equities	-0.60%	2%	0.50%
Total	0.00%		0.35%

$$E(R_A) = \sum w_{P,i} E(R_{P,i}) - \sum w_{B,i} E(R_{B,i}) = 10.25\% - 9.90\% = 0.35\%$$

Alternatively,

$$E(R_A) = \sum \Delta w_i E(R_{B,i}) + \sum w_{P,i} E(R_{A,i}) = 0.00\% + 0.35\% = 0.35\%$$

It can be seen that all of the expected active return is attributable to security selection. The active weights do not contribute to any asset allocation return.

$$E(R_A) = E(R_P) - E(R_B) = \sum w_{Pi} E(R_{P,i}) - \sum w_{Bi} E(R_{B,i})$$

$$E(R_A) = \underbrace{\sum \Delta w_i E(R_{B,i})}_{\text{Active return due to asset allocation}} + \underbrace{\sum w_{P,i} E(R_{A,i})}_{\text{Active return due to security selection}}$$

$$E(R_{A,i}) = E(R_{P,i}) - E(R_{B,i})$$

LOS 50.b: Calculate and interpret the information ratio (ex post and ex ante) and contrast it to the Sharpe ratio

Sharpe ratio (SR) ➡ Is calculated as excess return per unit risk (standard deviation)

$$SR = \frac{R_P - R_F}{\sigma_P}$$

Sharpe ratio is unaffected by the addition of cash or leverage in the portfolio. A 50% allocation to the risk free asset would reduce both the excess return and standard deviation of returns by half

Information ratio (IR) ➡ Is the ratio of the active return to the standard deviation of active returns, which is known as **active risk**

$$IR = \frac{R_P - R_B}{\sigma(R_P - R_B)} = \frac{R_A}{\sigma_A} = \frac{\text{active return}}{\text{active risk}}$$

Unlike Sharpe ratio, the Information ratio will change with the addition of cash or the use of leverage

LOS 50.b: Calculate and interpret the information ratio (ex post and ex ante) and contrast it to the Sharpe ratio

- For an unconstrained active portfolio, ***the optimal amount of active risk is the level of active risk that maximizes the portfolio's Sharpe ratio***

$$\sigma_A^* = \frac{IR}{SR_B} \sigma_B$$

- ***The Sharpe ratio of a portfolio with optimal level of active risk*** can be calculated as:

$$SR_P = \sqrt{SR_B^2 + IR^2} \quad \longleftrightarrow \quad IR^2 = SR_P^2 - SR_B^2$$

- The total risk of the portfolio is given by:

$$\sigma_P^2 = \sigma_B^2 + \sigma_A^2$$

LOS 50.b: Calculate and interpret the information ratio (ex post and ex ante) and contrast it to the Sharpe ratio

EXAMPLE: Optimal active risk

Omega fund has an information ratio of 0.2 and active risk of 9%. The benchmark portfolio has a Sharpe ratio of 0.4 and total risk of 12%. If a portfolio (portfolio P) with an optimal level of active risk has been constructed by combining Omega fund and the benchmark portfolio, calculate:

- Portfolio P's Sharpe ratio.
- Portfolio P's excess return (i.e., return above the risk-free rate).
- The proportion of benchmark and Omega fund in portfolio P.

Answer:

$$1. \text{ Optimal active risk} = \sigma_A^* = \frac{IR}{SR_B} \sigma_B = \frac{0.2}{0.4} (12\%) = 6\%$$

Based on Omega's information ratio of 0.2, the Sharpe ratio of portfolio P with an optimal level of active risk will be $(0.4^2 + 0.2^2)^{1/2} = 0.4472$

- The expected active return given an active risk of 6% is:

$$E(R_A) = IR \times \sigma_A = 0.2 \times 0.06 = 1.2\% = (R_P - R_B)$$

Given the benchmark Sharpe ratio of 0.4 and a benchmark total risk of 12%,

$$0.40 = \frac{R_B - R_F}{\sigma_P} = \frac{R_B - R_F}{0.12}$$

Therefore,

$$(R_B - R_F) = 4.8\%,$$

$$\text{portfolio P's excess return} = (R_P - R_F) = (R_P - R_B) + (R_B - R_F) = 1.2\% + 4.8\% = 6.0\%,$$

$$\text{and } \sigma_P^2 = 0.12^2 + 0.06^2 = 0.018 \text{ and } \sigma_P = 0.134$$

The Sharpe ratio of portfolio P then is: $SR = 6\% / 13.4\% = 0.4472$ (as calculated before).

- The optimal level of active risk is 6% and Omega fund has an active risk of 9%, so we can calculate that $6\% / 9\% = 67\%$ of portfolio P's allocation will be to the Omega fund and 33% to the benchmark portfolio.

$$\sigma_A^* = \frac{IR}{SR_B} \sigma_B$$

$$SR_P = \sqrt{SR_B^2 + IR^2}$$

SR of a portfolio with optimal level of active risk

$$IR = \frac{R_P - R_B}{\sigma(R_P - R_B)} = \frac{R_A}{\sigma_A} = \frac{\text{active return}}{\text{active risk}}$$

$$SR_B = \frac{R_B - R_F}{\sigma_B}$$

$$\sigma_P^2 = \sigma_B^2 + \sigma_A^2$$

$$SR_P = \frac{R_P - R_F}{\sigma_P}$$

SR of any portfolio

LOS 50.c: State and interpret the fundamental law of active portfolio management including its component terms-transfer coefficient, information coefficient, breadth, and active risk (aggressiveness)

➤ There are three factors that determine the Information Ratio (IR):

- Information Coefficient (IC)** ➡ is a measure of a manager's skill
- Transfer Coefficient (TC)** ➡ Degree of constraints on manager's active management
(can be thought as the correlation between active weights and optimal active weights)
- Breadth (BR)** ➡ Is the number of independent active bets taken per year

$$E(R_A) = IR \sigma_A$$


$$IR = (TC) IC \sqrt{BR}$$

$$E(R_A) = (TC) IC \sqrt{BR} \sigma_A$$

Fundamental Law

For an unconstrained portfolio TC = 1

For a constrained portfolio TC ≤ 1

LOS 50.d: Explain how the information ratio may be useful in investment management selection and choosing the level of active portfolio risk

- Portfolio theory concludes that **investors will choose some combination of the risk-free asset and an optimal risky portfolio**, with the weights **determined by their preference** (risk tolerance)

The optimal risky portfolio is the portfolio with the highest Sharpe ratio



The portfolio with the highest information ratio will also be the portfolio with the highest Sharpe ratio ($SR_P = \sqrt{SR_B^2 + IR^2}$)



So investors will choose the active manager with the highest information ratio regardless of their risk aversion

- Information ratio can be used to determine the expected active return for a given target level of active risk ➡ $E(R_A) = IR \sigma_A$

LOS 50.e: Compare active management strategies (including market timing and security selection) and evaluate strategy changes in terms of the fundamental law of active management

- Market timing is a bet on the direction of the market (e.g. an active manager may rotate money out of equities and into cash based on an expected decline in stock prices)
- For a market timer the Information coefficient is based on the proportion of correct calls IC = 2 (% correct) - 1 If the manager is correct 50% of the time, the IC will equal zero
- Market timing can also be used to make sector rotation decisions (e.g. an active manager may allocate assets into sectors that are expected to outperform)

Considering 2 sectors X and Y with expected returns and volatilities of return given by $E(R_X)$; $E(R_Y)$; σ_X ; σ_Y

- the active risk of a rotating strategy is the standard deviation of differential returns of the two sectors and is given by $\sigma_C = [\sigma_X^2 - 2\sigma_X\sigma_Y r_{XY} + \sigma_Y^2]^{1/2}$

Where r_{XY} is the correlation between the returns of sectors X and Y

- the annualized active risk = $\sigma_A = \sigma_C \times \sqrt{BR}$
- the annualized active return = $E(R_A) = IC \times \sqrt{BR} \times \sigma_A$



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LOS 50.e: Compare active management strategies (including market timing and security selection) and evaluate strategy changes in terms of the fundamental law of active management

EXAMPLE: Market timer vs. security selector

Darsh Bhansali is a manager with Optimus Capital. Bhansali, a market timer, makes quarterly asset allocation decisions based on his forecast of the direction of the market. Bhansali's forecasts are right 55% of the time.

Mike Neal is an equity analyst focusing on technology stocks. Neal, a security selector, typically makes 50 active stock selections annually. Neal has an information coefficient of 0.04.

Compute the information ratios of Bhansali and Neal assuming that both managers construct unconstrained portfolios.

Answer:

Because both portfolios are unconstrained, $TC = 1$.

Bhansali's $IC = 2(0.55) - 1 = 0.10$

Bhansali's $IR = IC\sqrt{BR} = (0.10)\sqrt{4} = 0.20$

Neal's $IR = IC\sqrt{BR} = (0.04)\sqrt{50} = 0.28$

$$IR = (TC) IC \sqrt{BR}$$

$$IC = 2 (\% \text{ correct}) - 1$$

LOS 50.e: Compare active management strategies (including market timing and security selection) and evaluate strategy changes in terms of the fundamental law of active management

EXAMPLE: Sector rotation

Hwang Soi makes monthly allocation decisions between consumer discretionary and consumer staples based on a proprietary model. The historical correlation between the returns of the two sectors is 0.30 and Soi's bets have been correct 60% of the time. Further information is in the following table.

Sector	E(R)	σ	Benchmark Weight
Consumer staples	10.8%	3.0%	65%
Consumer discretionary	13.2%	5.0%	35%

1. What is the annualized active risk of Soi's sector rotation strategy?
2. What is the expected annualized active return of Soi's sector rotation strategy?
3. What will be the allocation to the consumer discretionary sector if Soi feels that consumer staples will outperform the consumer discretionary sector over the next month and if the active risk is limited to 5.20%?

Answers:

1. Monthly active risk = $\sigma_c = [\sigma_X^2 - 2\sigma_X\sigma_Y r_{XY} + \sigma_Y^2]^{1/2}$

= $[0.03^2 - 2(0.03)(0.05)(0.30) + 0.05^2]^{1/2} = 0.05$ or 5%

Annualized active risk = $0.05 \times (12)^{1/2} = 0.1732$ or 17.32% $\longleftarrow$ the annualized active risk = $\sigma_A = \sigma_C \times \sqrt{BR}$

2. IC = $2(0.60) - 1 = 0.20$

Annualized active return = $IC \times \sqrt{BR} \times \sigma_A$ $\longleftarrow$ the annualized active return = $E(R_A) = IC \times \sqrt{BR} \times \sigma_A$

= $0.20 \times (12)^{1/2} \times 0.1732 = 0.12$ or 12%

Alternatively, active return from this strategy using a probability weighted average (given that Soi makes correct calls 60% of time) of combined risk is:

$(0.60)(0.05) + (0.40)(-0.05) = 0.01$ or 1% per month. $\longleftarrow$ % of correct calls $\times \sigma_C$ - % of incorrect calls $\times \sigma_C$

Annual active return = $1\% \times 12 = 12\%$.

3. If active risk is limited to 5.20%, the deviation from the benchmark weights of 65% and 35% is limited to $(5.20\% / 17.32\%) = 30\%$. When Soi feels that consumer staples will outperform, the allocation to that sector will be 65% + 30%, or 95%, and the allocation to consumer discretionary will be 5%.

LOS 50.f: Describe the practical strengths and limitations of the fundamental law of active management

- The fundamental law can be used to evaluate a range of active strategies, including security selection, market timing, and sector rotation, but one has to be aware of its practical limitations

- The limitations of fundamental law are generally derived from inaccurate estimates of the two inputs
 - Ex-ante measurement of skill ➡ The Information coefficient is an estimate of the accuracy of an active manager's forecast on an ex ante basis. One problem is that managers tend to overestimate their ability to outperform the market and, hence, overestimate their IC. (The accuracy of the IC determines the accuracy of the ex ante IR)

 - Independence ➡ The breadth of a strategy is meant to measure the number of truly independent decisions that an active manager makes. If two or more decisions rely on same (or similar) information, then they are not independent
Lack of true independence while measuring breadth of an active strategy may lead to an incorrect measure of breadth



Algorithmic Trading and High-Frequency Trading

Study Session 17

Reading Number 51



PM – Algorithmic Trading and High-Frequency Trading

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LOS 51.a: Define algorithmic trading

- An algorithm is a set of rules or a process followed by a computer to reach an end result
- **Algorithm trading** is a trading strategy that has been automated through the use of a computer
- Algorithm trading generally replicates the decisions a human trader would make and the orders they would place, but at speeds thousands of times faster

LOS 51.b: Distinguish between execution algorithms and high-frequency trading algorithms

Execution Algorithms



The objective of an execution algorithm is to execute large orders with minimal price impact (and without other market participants taking notice)

Execution algorithms generally slice a large order into smaller pieces and execute them in a way that minimizes price impact

High-Frequency Trading Algorithms



Are used to analyze real-time market data in search of patterns that can be profitably traded ("high frequency" refers to the frequency with which data gets updated)

These algorithms identify and execute trades in milliseconds. Usually the securities are held only for a short time (generally less than a day and sometimes less than a second)

LOS 51.c: Describe types of execution algorithms and high-frequency trading algorithms

TYPES OF EXECUTION ALGORITHMS

Volume weighted average price (VWAP) Algorithms



Split an order into pieces sized proportionally to the security's historical pattern over a day, so that larger pieces get executed during times of the day when market depth is greater

Implementation shortfall Algorithms



These algorithms attempt to strike a balance between minimizing the potential market drift that may happen if an order takes a long time to execute, and minimizing the negative price impact that will result when an order is executed too quickly

In this way implementation shortfall algorithms, continually adjusts the speed at which a trade executes as market conditions change in an attempt to minimize the difference between the decision price and the final execution price

Market Participation Algorithms



These algorithms cut a large order into slices that vary in size proportionally with actual trading volume

LOS 51.c: Describe types of execution algorithms and high-frequency trading algorithms

TYPES OF HIGH-FREQUENCY TRADING ALGORITHMS

1.- Statistical arbitrage Algorithms

➡ Identify securities that have historically moved together but have diverged recently. The algorithm will buy one security and sell the other so as to realize a profit when they eventually converge

- Pairs trading ➡ When prices of two securities diverge from their historically correlated movements, the outperforming security is shorted while the underperforming security is purchased. A profit will be earned if relative prices converge
- Index arbitrage ➡ Seek out temporary differences in price performance between securities and the sector to which they belong
- Basket trading ➡ Apply statistical arbitrage strategies to groups of securities, rather than to individual securities
- Spread trading ➡ Is a type of statistical arbitrage that takes long and short positions in two closely-related futures contract, in the notion that the spread between the two will change
- Mean reversion ➡ These algorithms are based on the idea that when the price of a security drifts away from its recent historical mean, its price will likely move back towards that mean
- Delta neutral strategies ➡ These strategies are designed to produce a small profit regardless of whether the market goes up or down. By combining securities such as stocks and options in such a way that the total delta of all of the securities is zero, the strategy may be able to make a profit from volatility changes or as the options approach to maturity

LOS 51.c: Describe types of execution algorithms and high-frequency trading algorithms

TYPES OF HIGH-FREQUENCY TRADING ALGORITHMS

2.- Liquidity aggregation and smart order routing



Market fragmentation can lead to price differences across markets and lack of liquidity within an individual market. These algorithms deal with market fragmentation by sending each order to the market with the best combination of price and liquidity (“smart order routing”), or by spreading the order over several trading venues (“liquidity aggregation”)

3.- Real-time pricing of securities



Use algorithmic trading tools to derive instantaneous price and liquidity information from the market itself

4.- Trading on news



Algorithms that react (in fraction of a second, and without human intervention) to breaking news stories and new economic data. These method have been boosted by the increasing availability of high-frequency news feeds, including feeds that contain tags that identify key statistics

5.- Genetic tuning



Refers to a self-evolving (“Darwinian trading”) system that test the performance of many different strategies by feeding live market data to each. Implements profitable strategies in the markets, and kills off money-losers. Strategies that earn profit are allowed to continue to evolve and pursue emerging opportunities

LOS 51.d: Describe market fragmentation and its effects on how trades are placed

Market fragmentation ➡ Refers to when the same security is traded in multiple financial markets
The downside of market fragmentation is the potential for price and liquidity differences across markets

- **Liquidity aggregators** make use of a concept called a “super book”, which adds up the liquidity available for an individual instrument across multiple markets
- **Smart order routing** is then used to direct orders to the market with the best combination of liquidity and price

Latency refers to the time lag between market data being released (or generated) and a corresponding trade being placed
Traders seek out the shortest possible latency times

LOS 51.e: Describe the use of technology in risk management and regulatory oversight

➤ Two methods of using algorithmic techniques to mitigate trading risk are as follows:

1.- Real-time pre-trade risk firewall



Constantly calculate risk exposures on the trades to ensure that risk limits are not exceeded. Trades that would exceed limits are blocked

Furthermore, the tools can be used to block erroneous trades (e.g. “fat finger” trades)

2.- Back-testing and market simulation



Testing algorithms to see how they perform under various offline scenarios.

Market simulators are used, along with either historical data or some invented scenarios



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LOS 51.e: Describe the use of technology in risk management and regulatory oversight

- Real-time market monitoring and surveillance refers to the practice of scrutinizing markets continuously in order to identify abnormal movements. Unusual and dramatic changes in volume or price for a security can provide advanced warning of issues in the markets. Kinds of suspicious trading that such regulators might be looking for include:
 - **Insider trading:** When a trader makes a large transaction in a security that they do not trade regularly and the trade turns out to be profitable due to news that breaks later
 - **Front running:** When a trader has advance knowledge of a large buy order and trades slightly earlier to profit from the price movement that the large transaction will cause
 - **“Painting the tape”:** In this scenario, a trader who wishes to sell a large quantity of a security first buys small quantities of the same security in order to drive up the market price.



LOS 51.e: Describe the use of technology in risk management and regulatory oversight

- **Fictitious orders:** Traders submit fictitious orders to move the market price or to induce other algorithms to make unwise trades
 - **Quote stuffing:** the algorithm injects a large number of orders and then almost immediately cancels them
 - **Layering:** the algorithm places genuine orders on one side of the market but also places layers of fake orders on the other side of the market. The purpose of the false orders is to induce market participants to transact with the genuine orders
 - **Spoofing:** the algorithm places orders between the bid and ask price with the intention of canceling these trades before they execute (intended to create false pessimism or optimism)
- **Wash trading:** The algorithm buys and sells the same securities repeatedly, in order to create false trading volume and increase buyer interest in a security that the trader wishes to sell
- **Trader collusion:** Multiple traders conspire to sway markets in a direction that is favorable to them



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LOS 51.f: Describe issues and concerns related to the impact of algorithmic and high-frequency trading on securities markets

POSITIVE IMPACTS OF ALGORITHMIC AND HIGH-FREQUENCY TRADING

- Facilitates large trades
- Increased liquidity
- Lower costs
- Tighter bid-ask spreads
- Improved pricing efficiency
- Promotes open and competitive markets
- Increased competition between trading venues



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LOS 51.f: Describe issues and concerns related to the impact of algorithmic and high-frequency trading on securities markets

CONCERNS REGARDING THE IMPACTS OF ALGORITHMIC AND HIGH-FREQUENCY TRADING

- Unfair speed advantage
- Magnification of market movements
- Market manipulation
- Risk of trading errors
- Out-of-control algorithms
- Denial-of-service
- Slowed markets due to excessive orders
- Increased difficulty of policing the market
- Unequal access to information

Despite the negative press, a broader analysis suggests that the advent of high-frequency trading has brought constructive changes to markets overall