Introduction to Finance

CY Cergy Paris University

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3. Make investment decision using the appropriate investment decision rule.

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 - Central in finance and in economics in general
 - Has to do with the fundamental uncertainty of future.
 - Has to do with r.
- How can financial risk be managed?

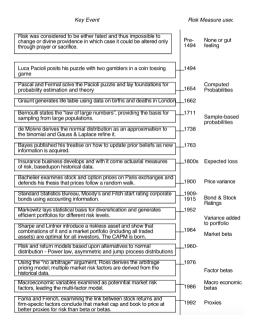
Risk Definition

- Knight (1921): Risk is uncertainty that you can quantify.
 - Risk is generally seen as negative.
 - Risk is actually dual as it can provide good and bad outcomes.
 - A business that works is not a business that avoids risk but a business that weight risk in a good way.

Risk

- Risk in business has become more and more important with long-distance trade.
- You need to put contracts in place, insurances, invest a lot and might not see a return, etc.
 - But the investor does not suffer physically from the risk.
 - Finance separates economic risk from financial risk.





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 - U.S. Long-term treasury bonds: risk of interest rate change (price fall when interest rate increase).
 - A portfolio of U.S. stocks: riskier, depends on the above risk and on the performance of companies.

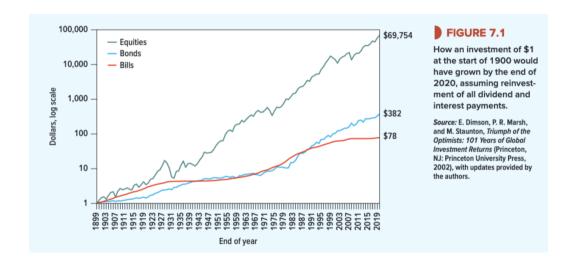
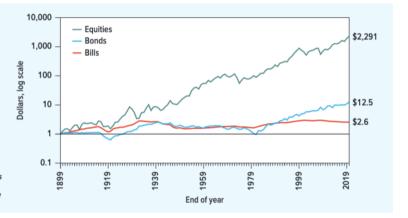


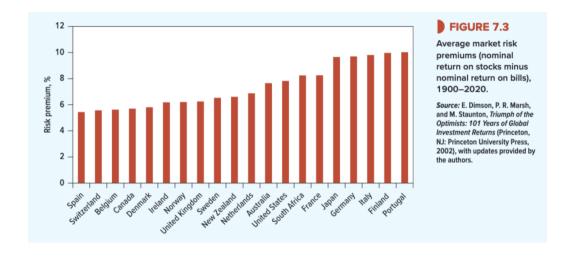
FIGURE 7.2

How an investment of \$1 at the start of 1900 would have grown in real terms by the end of 2020, assuming reinvestment of all dividend and interest payments. Compare this plot with Figure 7.1, and note how inflation has eroded the purchasing power of returns to investors.

Source: E. Dimson, P. R. Marsh, and M. Staunton, *Triumph of the Optimists:* 101 Years of Global Investment Returns (Princeton, NJ: Princeton University Press, 2002), with updates provided by the authors:



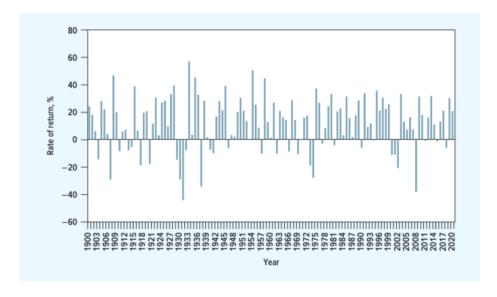
	Average Annual Rate of Return					
	Average Risk Premium (E Nominal Real Return versus Treasury E					
Treasury bills	3.7%	0.9%	0%			
Government bonds	5.4	2.6	1.7			
Stocks	11.5	8.5	7.8			



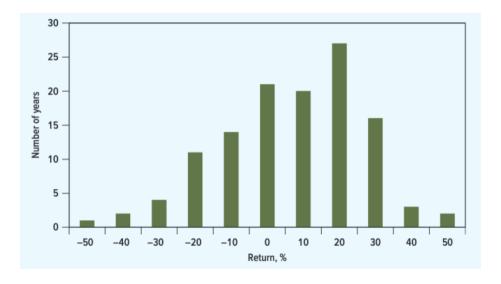
- Returns seems correlated with risk: low risk investments offer low returns.
- Take r_m , the expected return of the market (think about S&P500 or CAC40 in France).
- Past performance can help understand future performance but it is not a perfect predictor.
 - Return is the sum of the risk-free interest rate (r_f) and the risk premium.
 - Both are affected by changes in interest rate, macroeconomic conditions, policies, etc.
- Approximation: take today r_f and add the observed past risk premium (7.8%).
- Assuming $r_f = 2\%$, what is r_m ?

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- Assuming $r_f = 2\%$, what is r_m ? $r_m = 9.8\%$.
- Assumption that there is a stable risk premium on equity.
- Evaluating risk involves a lot of uncertainty and heterogeneity among actors.

Risk premium does not come for free



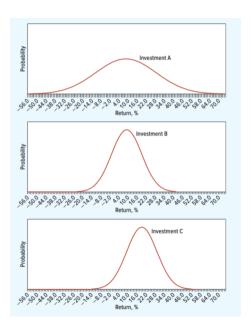
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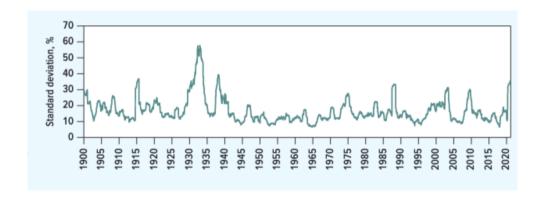
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- Remark that the distribution of returns looks like a normal curve.
 - Nice property: normal curves are defined by only two parameters: mean and variance.
- Variance is the mean of squared deviations to the mean: $V(r_i) = \sigma_{r_i}^2 = \frac{1}{n} \sum_k (r_k \bar{r_i})^2$
- Standard deviation is the square root of variance: $\sigma_{r_i} = \sqrt{V(r_i)}$



Portfolio	Standard Deviation (σ)	Variance (σ²)
Treasury bills	2.8%	8.1
Government bonds	8.9	79.7
Stocks	19.5	381.8



Standard Deviation (σ)									
	Stock	Market		Stock	Market				
BHP Billiton (Australia)	26.2%	10.9%	Sanofi (France)	17.5%	14.0%				
BP (U.K.)	22.8	11.3	Nestlé (Switzerland)	13.6	10.9				
Siemens (Germany)	22.5	15.5	Sony (Japan)	27.6	16.4				
Hyundai Heavy Industry (Korea)	40.7	12.5	Toronto-Dominion Bank (Canada)	12.0	9.1				
Agricultural Bank (China)	25.5	18.5	Tata Motors (India)	45.3	15.0				

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- Mathematical property: Standard deviation of a mean (e.g. a market) is not the mean of the standard deviations.

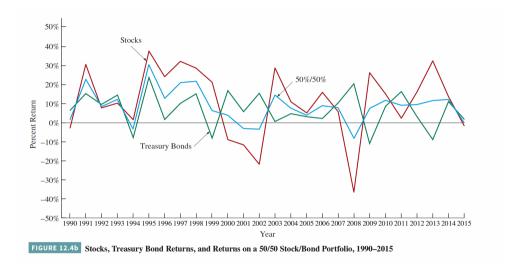
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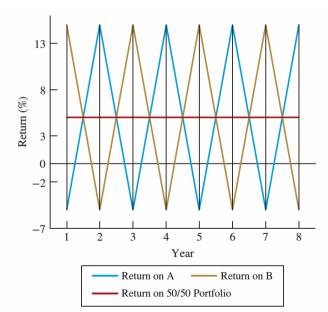
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- For a portfolio with weights ω : $V(\omega_X X + \omega_Y Y) = \omega_X^2 V(X) + \omega_Y^2 V(Y) + 2\omega_X \omega_Y \rho_{XY} \sigma_X \sigma_Y$ with ρ_{XY} the correlation between X and Y





	Stock 1	Stock 2
Monthly return	1.5%	2.5%
Standard deviation (σ)	10%	15%
Correlation Stock 1-Stock 2 (ρ_{12})	0.2	

- Compute the return and its standard deviation when you invest half on each stock.
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 - $V(portfolio) = 0.5^2 * 0.1^2 + 0.5^2 * 0.15^2 + 2 * 0.5 * 0.5 * 0.1 * 0.15 * (-1) = 0.000625$ so $\sigma = \sqrt{0.000625} = 0.025$

Where does risk come from?

- There are two types of risk: **specific risk** and **systematic risk**.
- **Specific risk** only affects one company, or a group of company, an industry, etc.
 - e.g. A shock on food price will affect food distributors but not the aeronautic industry.
 - This risk is diversifiable through a well-diversified portfolio.
- **Systematic or undiversifiable risk** are shared by most businesses. A stock market crisis, macro-economic shocks, etc.
- Total risk is the sum of both risks.

Where does risk come from?

Diversifiable Risk (also known as unsystematic risk or firm-specific risk, or micro risk)	Undiversifiable Risk (also known as systematic risk, market risk, or macro risk)
Business Risk	Market Risk
Financial Risk	Interest Rate Risk
Event Risk	Purchasing Power Risk
Tax Risk	Exchange Rate Risk
Liquidity Risk	

Where does risk come from?

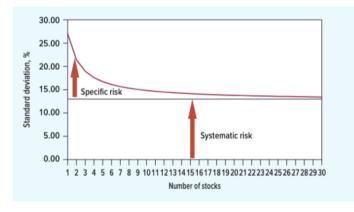
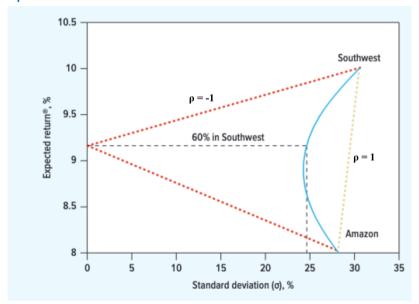


FIGURE 7.12

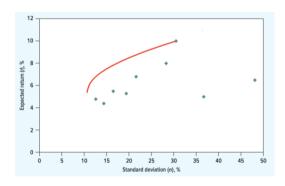
Average risk (standard deviation) of portfolios containing different numbers of stocks. The stocks were selected randomly from stocks traded on the New York Stock Exchange from 2010 through 2019. Notice that diversification reduces risk rapidly at first, then more slowly. This is because diversification can only eliminate specific risk. It cannot eliminate systematic risk.

- What's the best portfolio to hold?

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- That's exactly the question Harry Markowitz asked in 1952.
- The *investment opportunity set* represents all the available combinations of risk and return.
- **Efficient portfolios** is the set of the best portfolio you can achieve with a given investment strategy.
- The market portfolio is the one that aggregates all stocks.
- Its return and standard deviation is easy to compute.



- Each dot represents a stock.
- Many combinations between them is possible.
- The red line shows efficient portofolios, those that allow the best return-to-risk ratios.



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- Remember the risk-free asset r_f ? It's going to be key.
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- Return = $(\omega_f r_f + \omega_p r_p)$, $\sigma = \omega_p \sigma_p$ because $\sigma_f = 0$

- The range of opportunity can be written as a straight line.

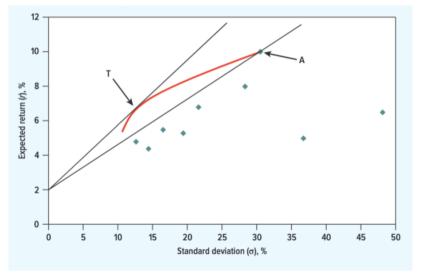
- The range of opportunity can be written as a straight line.
- The return formula and the σ formula can be seen as a system of equation.

$$\begin{cases} r = \omega_f r_f + \omega_p r_p \\ \sigma = \omega_p \sigma_p \end{cases}$$

- Using $\omega_p = \frac{\sigma}{\sigma_p}$ and $\omega_f = 1 - \omega_p$:

$$r = r_f + \frac{r_p - r_f}{\sigma_p} \sigma$$

Lending and borrowing extend the range of opportunity



- The slope of the line is: $\frac{r_p - r_f}{\sigma_p}$.

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- Lending and borrowing extend the range of opportunity with better alternatives.
- What's the best choice?
- Choice with the highest Sharpe ratio (efficiency) that touches the investment set (constraint) → tangent to point T.
- Investors will hold the same portfolio T and a different combination of borrowing and lending according to their risk profile.
- But... only true if all investors have the same information: expected returns, standard deviations and correlations \longrightarrow efficient markets.

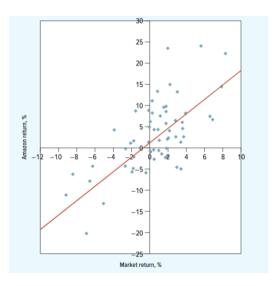
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- It is the **market portfolio** *i.e.* the portfolio of all stocks in the economy, where the weights correspond to the fraction of the overall market that each stock represents.
- Thanks to this, all specific risk is diversified away. The risk that remains is market risk.
 - The risk of a well-diversified portfolio depends on the market risk of the securities included in the portfolio.
- The line is called the Capital Market Line. It shows the best trade-off between risk and return.
- Its Sharpe ratio is: $\frac{r_m r_f}{\sigma_m}$
- → All investors should hold the same portofolio, which is the market portofolio.

Market risk

- The risk that a stock contributes to a well-diversified portfolio is its **market risk**.
 - The specific risk is diversified away and investors are only compensated for bearing non-diversifiable risk.
- How to compute market risk, the risk that a stock shares with the market?
 - How sensitive a stock is to market movements.
 - It's called β .
- $\beta_i = \frac{\sigma_{iM}}{\sigma_M^2}$
- with σ_{iM} the covariance between a stock return and the market return and σ_M^2 the variance of the market return.

- It simply corresponds to the line of best linear fit (or OLS) between r_i and r_m .
- The return on Amazon increases on average by 1.55% when the market return increases by 1%.
- Its beta is 1.55.



Market risk

- Stocks with $\beta > 1$ move more than proportionally with the market.
 - e.g. Luxury companies
- Stocks with $0 < \beta < 1$ move less than proportionally with the market.
 - e.g. Necessity companies
- The β of a portfolio is simply the weighted average of individual β_i .
- Interpretation: A well-diversified portfolio with a beta of 1.5 will end up with 150% of the market's risk.
- When the market rises by 1%, the price of the stock will increase by 1.5%. When the market falls by 2%, its price will fall by 3%.

Market risk

Stock	Beta (β)	Stock	Beta (β)
Tata Motors (India)	1.83	Sony (Japan)	0.82
Hyundai Heavy Industry (Korea)	1.44	BHP Billiton (Australia)	0.80
BP (UK)	1.33	Agricultural Bank (China)	0.74
Siemens (Germany)	1.21	Sanofi (France)	0.55
Toronto Dominion Bank (Canada)	0.89	Nestlé (Switzerland)	0.11

- How much extra return should earn an investor that bear market risk?
- Capital Market Line: $r_p = r_f + \frac{r_M r_f}{\sigma_M} \sigma_p \longrightarrow$ expected return for an efficient portfolio with borrowing and lending.
- An investor should not be rewarded for diversifiable risk. Only for market risk.
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- One of the most famous equation in finance: the equation of the Capital Asset Pricing Model (CAPM).

The Capital Asset Pricing Model (CAPM)

- The CAPM defines a fundamental relationship between risk and return.
- In a competitive market, the expected risk premium on any security or portfolio, is its β multiplied by the market risk premium.
- e.g. the expected risk premium on an investment with a β of 0.5 is half the expected risk premium on the market.
- β is a very useful (and simple) measure of risk.
- Assumptions behind the CAPM: all investors and mean-variance optimizers, they can borrow/lend at the risk-free rate, they face the same information and beliefs.

The Capital Asset Pricing Model (CAPM)

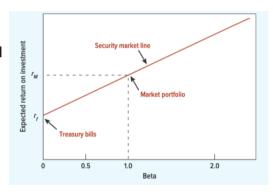
The Security Market Line

- The **security market line** plots the relationship between β and return.
- Treasury bills have a $\beta = 0$ and a risk premium of zero.
- The market portfolio has $\beta = 1$ and a risk premium of $r_M r_f$.

The Capital Asset Pricing Model (CAPM)

The Security Market Line

- The CAPM states that the expected risk premium on each investment is proportional to its beta.
- Each investment should line on the SML, connecting treasury bills and the market portfolio.



- The CAPM helps to estimate the cost of equity.
 - Opportunity cost of holding the equity of the firm.
 - Foregone return for investors of holding other firms' equity with similar risk.
- To compute it, we need:
 - 1. Which alternative projects should be used to compare the current firm to.
 - 2. Forecast the returns from investing in these alternative opportunities.
- When assets are risky, (risk-averse) investors need to be compensated for bearing the risk of that asset in excess of holding a risk-free asset.
- **CAPM:** $r_i r_f = \beta_i (r_M r_f)$
- The only stock-specific variable is the β :measure of how the stock's return move with the market.

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$$r_i = r_f + \beta_i (r_M - r_f)$$

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- β_i
- Use past returns of projects/firms in the same industry.
- Look at how the return of the stock move with the market return.
- If returns are not available for the firm/project, find comparable public companies (a *pure play*) and take their average beta.







- This method will give the equity beta of the pure plays.
- To get the asset's beta, we need to unlever the beta:

$$\beta_{A} = \frac{E}{E+D}\beta_{E} + \frac{D}{E+D}\beta_{D}$$

- β_D is the covariance between the pure play's return on its debt and the market return.
 - Hard to observe but for investment grade debt (above BBB), we can assume that β_D is zero. Otherwise it is likely to be small.

Company	Equity-to-assets ratio	Equity beta	Debt beta
General American Oil	0.85	1.81	0
Flight Airlines	0.5	2	0.25
Everything Conglo	0.95	1.1	0
Louisiana Oil	0.63	2.36	0.12
Mesa Petroleum	0.77	1.9	0.05

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Mesa Petroleum	0.77	1.9	0.05

-
$$\beta_{GAO} = 0.85 * 1.81 + 0.15 * 0 = 1.539$$

Company	Equity-to-assets ratio	Equity beta	Debt beta
General American Oil	0.85	1.81	0
Flight Airlines	0.5	2	0.25
Everything Conglo	0.95	1.1	0
Louisiana Oil	0.63	2.36	0.12
Mesa Petroleum	0.77	1.9	0.05

-
$$\beta_{GAO} = 0.85 * 1.81 + 0.15 * 0 = 1.539$$

-
$$\beta_{LO} = 0.63 * 2.36 + 0.37 * 0.12 = 1.531$$

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-
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-
$$\beta_{MP} = 0.77 * 1.9 + 0.23 * 0.05 = 1.475$$

- General Conglomerates is evaluating an oil exploration project proposed by the manager of its aviation division

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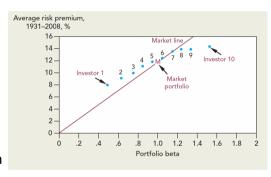
-
$$\beta_{LO} = 0.63 * 2.36 + 0.37 * 0.12 = 1.531$$

-
$$\beta_{MP} = 0.77 * 1.9 + 0.23 * 0.05 = 1.475$$

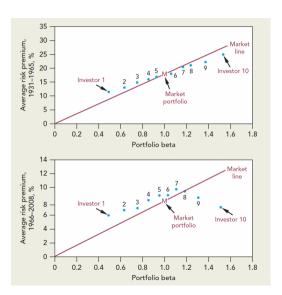
- Average is 1.515.

- The CAPM is a model and therefore simplifies the reality.
- But it is useful to understand the risk associated to a stock.
 - 73% of investors use it to compute the cost of capital (Graham and Harvey, 2001).
 - Alternative is to use the DCF formula to get $r_E = \frac{DIV_1}{P_0} + g$ (cf. last lecture) but it is less common.
- Does it hold in real life?

- Investor 1 invests in the stocks that have betas in the first decile, Investor 2 in those that have betas in the second decile
- In the CAPM, any investment should lie on the SML.
- The positive and linear relationship between beta and risk hold.
- But with a smaller slope.



- The relationship is less sharp in the recent years.



- Lines correspond to the cumulative difference in returns for two different types of stocks.
- In the CAPM, the only reason for different returns is the beta.
- Invalidated by the figure which shows other determinants of return.

